PB86-139375

Bibliography on Indoor Air Pollution

(U.S.) Environmental Protection Agency
Washington, DC

Jun 85

U.S. Department of Commerce
National Technical Information Service
NTIS

United States
Environmental Protection
Agency

Information Services
and Library
Washington DC 20460

PB86-139375

EPA

Bibliographic Series

Indoor Air Pollution

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

91

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA/IMSD-85-002	2.	3. RECIPIENT'S ACCESSION NO. PB86 139375/AS
4. TITLE AND SUBTITLE Bibliography on Indoor Air Pollution		5. REPORT DATE June 1985
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO. EPA/IMSD-85-002
9. PERFORMING ORGANIZATION NAME AND ADDRESS Information Services and Library / PM-211a United States Environmental Protection Agency 401 M St. SW Washington, DC 20460		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS		13. TYPE OF REPORT AND PERIOD COVERED Bibliography
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Bibliographic Series of the Environmental Protection Agency Information Services and Library

16. ABSTRACT

A bibliography on Indoor Air Pollution, which highlights Sources of Indoor Air Pollution, Factors Contributing to Indoor Air Pollution, the Health Effects of Indoor Air Pollution, and Measures to Mitigate Indoor Air Pollution.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
	Indoor Air Pollution Health Effects	

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
	20. SECURITY CLASS *(This page)*	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

BIBLIOGRAPHY ON

INDOOR AIR POLLUTION

JUNE 1985

Headquarters Library Staff
Information Management and Services Division
U.S. Environmental Protection Agency
401 M Street, S.W. PM-211A
Washington, D.C. 20460
(202) 382-5922

PREFACE

The Bibliography on Indoor Air Pollution was prepared at the request of the Offices of Pesticides and Toxic Substances, and Air and Radiation. It is a selective, annotated listing of information sources on the increasingly important topic of residential and industrial indoor air pollution. The EPA Headquarters Library staff compiled the Bibliography under the direction of the Chief, Information Services Branch, Information Management and Services Division, Office of Information Resources Management.

The Library staff wishes to gratefully acknowledge the invaluable assistance of Mr. Timothy R. Titus, Deputy Director, Existing Chemical Assessment Division, Office of Toxic Substances, and Dr. David H. Mudarri, Special Initiatives Officer, Office of Program Management Operations, Office of Air and Radiation, in the development of this bibliography. Special thanks are also due to Mr. Michael Bouchard, EPA Reference Librarian, for his thorough editorial review.

TABLE OF CONTENTS

Introduction.................................... i

I. Sources of Indoor Air Pollution.................. 1-1

II. Factors Contributing to Indoor Air Pollution...... 2-1

III. Health Effects of Indoor Air Pollution........... 3-1

IV. Measures to Mitigate Indoor Air Pollution......... 4-1

INTRODUCTION

The subject of indoor air pollution is a complex one. There are many EPA employees, other government agencies, outside groups and independent researchers interested in the problem. The purpose of this bibliography is to help answer the wide variety of requests for information about indoor air pollution. Consequently, it is organized according to four major topic areas: (1) sources, (2) contributing factors, (3) health effects, and (4) mitigation measures.

The citations include books, journal articles, government reports and conference papers. Within the four topic areas, citations are in alphabetical order by author's last name, or if there is no author, by title.

Citations preceded by an asterisk are held in the U.S. Environmental Protection Agency Library System. Other citations can be borrowed for EPA employees through interlibrary loan. An EPA librarian can assist in identifying other citations for further research on indoor air pollution.

In compiling the bibliography, the Library staff searched the databases listed below and interviewed selected EPA program staff. Citations found in databases were screened for relevance to the four topics of the bibliography. When available from the databases, abstracts are included in the bibliography. Each abstract is followed by a two-letter abbreviation that identifies its source. The databases and their abbreviations are listed below.

(CA) CAS Online
STN-Columbus
c/o Chemical Abstract Service
2540 Olentangy River Road
P.O. Box 2228
Columbus, OH 43202

(EN) Enviroline
Environment Information Center, Inc.
292 Madison Avenue
New York, NY 10017

(ME) Medline
Medlars Management Section
National Library of Medicine
8600 Rockville Pike
Bethesda, MD 20209

(NT) National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22041

(PA) Pollution Abstracts
Cambridge Scientific Abstacts
5161 River Road
Bethesda, MD 20816

We hope this bibliography is useful. If you have any questions or wish to obtain additional copies, please contact the EPA Headquarters Library staff at (202) 382-5921.

I. SOURCES OF INDOOR AIR POLLUTION

***Alfheim, I., et al. "Contribution of Wood Combustion to Indoor Air Pollution as Measured by Mutagenicity in Salmonella and Polycyclic Aromatic Hydrocarbon Concentration." Environmental Mutagenesis, Vol. 6, No. 2, 1984. (PA)**

Samples of airborn particles have been collected in the same room when heated by electricity and when heating was done by woodburning. These samples were compared with respect to mutagenic activity and concentration of polycyclic aromatic hydrocarbons (PAH). The effects of the various heating conditions were examined in the presence and absence of tobacco smoking. Whereas wood heating in an "airtight" stove was found to cause only minor changes in the concentration of PAH and no measurable increase of mutagenic activity of the indoor air, both of these parameters increased considerably when wood was burned in an open fireplace. The effects of wood burning in an open fireplace on the mutagenic activity of indoor air could still be considered moderate when compared to those resulting from tobacco smoking in the room as measured in the Salmonella assay with strain TA98 with metabolic activation.

***Becker, A.P. III, et al. Evaluation of Waterborne Radon Impact on Indoor Air Quality and Assessment of Control Options. NTIS, Springfield, VA, EPA/600/7-84/093. Sept. 1984. PB84-246404. (NT)**

This research program was conducted with two objectives: (1) evaluation of waterborne radon impact on indoor air quality, and (2) assessment of available control technologies to limit indoor exposure to radon and its decay products. This report contains a review of radon's physical, chemical and radiological properties; a summary of its decay chain; and a synopsis of health risks, existing regulations, and recommendations concerning exposure to radon and its progeny. This report also presents assessments of reported techniques for removal of radon from water or indoor air. Techniques evaluated for removal of radon from water include decay, aeration and granular activated carbon. Techniques evaluated for removal of radon and/or progeny from air include circulation, various types of ventilation, filtration, electrostatic precipitation, charcoal adsorption, chemical reaction, and space charging. Where the reports examined include a sufficient amount of information to do so, an evaluation of the cost, efficiency and practicality of each technique is provided.

***Becker, D.S., et al.** Organic Contaminants in Indoor Air and Their Relation to Outdoor Contaminants: Phase 2 - Statistical Analysis. **83-004945. (EN)**

Data were collected at 35 sites in and around Chicago to determine the relationship between indoor and outdoor air contaminants. The information was collected from samples of indoor air, samples of outdoor air, and data, consisting of 50 factors, for a site characterization survey. The air samples were analyzed using a MS/GC technique. Chi square analysis, clustering analysis and regression analysis were used in the statistical examination of the data. One conclusion was that indoor air contains a larger number of organic contaminants than outdoor air.

***Boeniger, M., et al.** Industrial Hygiene Survey Report of A. O. Smith Inland Incorporated, Little Rock, Arkansas. **NTIS, Springfield, VA, IWS-143.10. Feb. 1984. PB84-241751. (NT)**

Environmental and breathing zone samples were analyzed for 4,4'-methylenedianiline (MDA) at Smith Inland, Incorporated, Little Rock, Arkansas in July 1983. MDA was found in all air, dermal, and wipe samples. Ventilation measurements were taken in the upper level mixing rooms. Since MDA has been shown to be carcinogenic in laboratory animals, the authors recommend that an improved program of use of engineering controls and personal protective equipment be implemented. Specific recommendations include improving ventilation in the mixing room, use of natural latex gloves, identification of the emission sources of MDA generated by the heating resins, installation of local exhaust ventilation at these sources, and proper use of disposable dust respirators.

***Boeniger, M.** Industrial Hygiene Survey Report, Olin Corporation, Moundsville, West Virginia. **NTIS, Springfield, VA, IWS-143-12. Mar. 1984. PB84-243237. (NT)**

An industrial hygiene survey at the Olin Corporation, Moundsville, West Virginia was conducted in August 1983 to determine if a health hazard existed from 4,4'-methylenedianiline exposure. The facility employed 300 workers, most of whom were middle aged. Environmental and breathing zone samples were analyzed for MDA, as were dermal samples. Ventilation measurements were made. The author concludes that dermal contact with MDA probably affected only six employees. Recommendations include improving exhaust ventilation and the use of personal protective equipment.

Boleil, J., et al. "Indoor Air Pollution by Carbon Monoxide and Nitrogen Oxides; Innenluftverunreinigungen durch Kohlenmonoxid Und Stickstoffoxide." Luftqualitat in Innenraumen, 1982, pp. 199-208. (PA)

The results of an exploratory survey of indoor levels of carbon monoxide (CO) and nitrogen dioxide (NO_2) from gas-fired cooking and waterheating appliances in the Dutch cities of Arnheim and Enschede in the fall of 1980 are reported. Measurements were carried out electrochemically (Ecolyzer 2000) or with Draeger tubes in the case of CO and with Palmes diffusion tubes (5 to 8 days exposure) in the case of NO_2. For CO, in 18% (27%) of the homes visited the limit of 600 (300) ppm in the flue gases was exceeded in 17% of the homes. The arithmetic mean values of the NO_2 concentration in 286 homes was 118)g/m^3 with a range of 35 to 472)g/m^3. The corresponding figures for living rooms were 58 and 35 to 346)g/m^3, respectively. Outdoor NO_2 concentrations were 2 to 3 times lower than indoor concentrations.

***Brunekreef, Bert. "The Arnhem Lead Study. I. Lead Uptake by 1 to 3 Year Old Children Living in the Vicinity of a Secondary Lead Smelter in Arnhem, The Netherlands." Environmental Research, Vol. 25, No. 2, August 1981, p. 441. (EN)**

This epidemiological study was conducted in the vicinity of a secondary lead smelter in Arnhem, the Netherlands. Blood lead levels for one to three year old children were determined and proved to be slightly elevated. Lead in air, dustfall, soil, street dust, house dust, and drinking water was also measured. Analysis showed that lead levels in garden soil and dustfall indoors and outdoors were the most useful parameters in explaining the variance in the blood lead levels of the study population.

***Bruno, Ronald C. "Sources of Indoor Radon in Houses: A Review." Air Pollution Control Association Journal, Vol. 33, No. 2, Feb. 1983, p. 105. (EN)**

The primary sources of indoor radon are analyzed and discussed. These include soil gas, building materials, and tap water. Within the framework of a simple steady-state analysis of the radon concentration in a model of a typical house, the potential contribution to indoor radon levels from each source was determined. When these results are compared with reported file studies of radon in houses, it appears that the infiltration of soil gas directly into a house is by far the largest contributor to indoor radon levels.

***Cecala, A.B.,** **et al.** **New Bag Nozzle to Reduce Dust from Fluidized Air Bag Machines.** **NTIS, Springfield, VA, BUMINES-RI-8886. 1984. PB84-224484. (NT)**

A new prototype bag nozzle system has been designed under a Bureau of Mines contract to reduce dust generated during the bagging operation of fluidized air baggers. A field analysis of the new system has shown that the bag operator's dust exposure was reduced 83%. The amount of blowback was reduced 89%, which corresponds to a significant product saving. The new prototype system has been operating for a substantial period of time with no major problems.

***Chambers, D., et al. "Lead Levels in Exhaust Replacement Centres." Science of the Total Environment. Vol. 33, Feb. 15, 1985, p. 31. (EN)**

The atmospheric lead levels in three garages serving as automotive exhaust system replacement centers in the U.K. were documented. Airborne particulates and deposited dust samples were analyzed. Results show lead levels above those caused by ambient concentrations arising from vehicular emissions. The likely source of contamination is the dust removed from the internal surfaces of exhaust systems; the dust contained 24.9-58.7% lead during replacement operations. Dust with levels of 0.5-3% lead was deposited throughout the facilities.

***Chaplan, P.E. Control Technology Assessment of Solid Materials Handling, Phase 1 Bag Opening, Emptying, and Disposals, Delaware Valley, Inc., Bristol, Pennsylvania. NTIS, Springfield, VA, CT-144-18, May 1984. PB84-241926. (NT)**

A preliminary survey was conducted to assess control technology at Rohm and Haas Delaware Valley, Incorporated, Bristol, Pennsylvania, in May 1981. The ability of engineering controls, housekeeping, and work practices to control exposures to polyvinyl-chloride, acrylic resins and barium-cadmium-stearate dusts during the opening, emptying, and disposal of bags, containers, and powdered chemicals was investigated. Air concentrations of the dusts were not measured, as they were monitored by the company. The author concludes that the engineering controls, housekeeping procedures, and work practices are effective in controlling dust concentrations. An in depth survey is recommended.

Claydon, M.F., et al. Review of Bitumen Fume Exposures and Guidance on Measurement. NTIS, Springfield, VA, CONCAWE-6/84. 1984. PB84-225291. (NT)

Part I of the report reviews available data on exposure to bitumen fumes in various activities involving handling and use of bitumen. These data show that bitumen fume exposures are usually below the 8-hour time-weighted average exposure limit of 5 mg/m^3 recommended by the American Conference of Governmental Industrial Hygienists. However, this level can easily be exceeded in indoor applications if good ventilation is not provided. Inhalation exposures to polycyclic aromatic hydrocarbons also appear to be very low. The critique of the methodology for sampling and analysis of bitumen fumes (Part II) identifies aspects of sampling, filter weighing and solvent extraction of filters which require particular attention if reliable exposure measurements are to be obtained. These items are taken into account in Part III which provides a detailed methodology for determination of total particulate and benzene soluble personal exposures.

***Cote, William A., et al. A Study of Indoor Air Quality. NTIS Report PB-238 556, Sept. 1974. 75-006690. (EN)**

A study of indoor air quality was conducted for 15 months. The program consisted of laboratory investigations, field studies, and an inventory of indoor sources. Tasks 1 and 2 established the emissions and effect on air quality of gas stoves and heaters both in the laboratory and in four homes. Task 3 developed information on indoor sources of air contamination in typical Southern New England homes, and also on the effects of products and of their use on indoor air quality.

***Diemel, Jodokus A., et al. "The Arnhem Lead Study. II. Indoor Pollution, and Indoor/Outdoor Relationships." Environmental Research, Vol. 25, No. 2, Aug. 1981, p. 449. (EN)**

An extensive investigation was carried out on the lead content of house dust collected near a lead smelter in Arnhem, the Netherlands. Samples were taken of ambient air indoors, lead deposition indoors, and floor and window dust. Indoor pollution levels were lower than the corresponding outdoor levels. Statistical analyses show that in Arnhem, lead is carried into houses in the form of lead particles that adhere to shoes and clothing.

***Dimmick, Robert L., et al. "Problems of Measuring Numbers of Microbes in Occupied Spaces." Emerging Environmental Solutions for 80s, Los Angeles, Vol. 2, May 5-7, 1981, p. 97. 82-004873. (EN)**

Problems associated with sampling air for viable microbes are discussed. Even though sampling is expensive and often yields confusing data, scientific curiosity provides support for its continued use. Being able to locate airborne microbes is an important aspect of air sampling. Differences between before and after-the-fact studies are explained.

***Dobbs, A.J., _et al_. "Indoor Air Pollution from Pesticides Used in Wood Remedial Treatments." _Environmental Pollution: Series B_, Vol. 6, 1983, p. 271. (EN)**

Air samples were collected from inside houses that had been given commercial remedial treatments to combat wood-boring insects or dry rot. Measured concentrations of Gamma-Hexachlorocyclohexane (Gamma-HCH), Dieldrin, and Pentachlorophenol (PCP) are reported. In the absence of guidelines for safe concentrations of these chemicals in homes, acceptable air concentrations were derived from acceptable daily intake values implemented in the U.K. Assuming that inhalation is the sole route of exposure, documented Dieldrin levels are in excess of the acceptable concentrations; results from Gamma-HCH and PCB are below acceptable levels.

***Douville, Judith A. "The Chemical Nature of Indoor Air Pollution." _Dangerous Properties of Industrial Materials Report_, Vol. 4, No. 3, May-June 1984, pp. 2-8. 84-005622. (EN)**

As formal indoor air standards do not exist, more research is needed to ascertain average and permissible levels of indoor air pollutants. Building materials, appliances, and other consumer products are major sources of indoor air contaminants. Cigarette smoke and wood-burning fireplaces contribute to elevated levels of interior benzo-a-pyrene, carbon monoxide, and carbon dioxide. Radon and asbestos emitted by insulation and building materials have been recognized as potential health hazards.

***Dudney, C.S., _et al_. _Report of Ad Hoc Task Force on Indoor Air Pollution_. NTIS, Springfield, VA. 1981. ORNL/TM-7679. (PA)**

The quality of air within a man-made structure is likely to be affected by energy conserving modifications made on that structure. Information was reviewed on indoor air pollution and the potential impact on human health of energy efficient residences. Studies that have been done and those in progress indicate that the indoor air pollution may significantly affect human health. The task force concluded from its investigations that: (1) the indoor environment is likely to include exposure to radon daughter nuclides, formaldehyde, carbon monoxide, nitrogen dioxide, respirable particulates, and asbestos, as well as other undefined pollutants; (2) indoor exposure may constitute 80 to 95% of the total exposure for some pollutants; (3) studies have not been done to provide a basis for adequate assessment of indoor air quality.

***Draft Criteria Document for Vinyl Chloride. Environmental Protection Agency, Criteria and Standards Division. NTIS, Springfield, VA, Feb. 1984. PB84-199538. (NT)**

This document summarizes the health effects of Vinyl Chloride. Topics include: General Information and Properties; Human Exposure; Pharmacokinetics; Health Effects in Animals and Humans; Mechanisms of Toxicity; Risk Assessment and Quantification to Toxicological Effects.

***Fingerhut, M., et al. NIOSH Dioxin Registry Site Visit Report of Rhone-Poulenc Incorporated, Portland, Oregon. NTIS, Springfield, VA, IWS-117-14. Jan. 31, 1984. PB84-240035. (NT)**

Worker exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin were assessed at Rhone Poulenc, Incorporated, Portland, Oregon in January 1982. The survey was conducted to evaluate the feasibility of including workers involved with the synthesis of 2,4,5-trichlorophenoxyacetic acid in the dioxin registry. Complete personnel records were kept for all workers beginning in 1960. Limited medical information was available. Processes in the production of 2,4,5-T, its isooctyl and isobutyl esters, the formulation and packaging of its esters, and the production of its triethylamine salt were assessed. Formulation included blending the complete acids and esters and mixing the solutions to the proper strengths. Synthesis, dilution, and addition of additives and filtering were part of the formulation operation for amines. The same equipment was used for processing 2,4,5-T and 2,4-dichlorophenoxyacetic acid. No pressure releases or blow outs occurred during processing. No industrial hygiene data on worker exposures to process materials was available. No analysis for dioxin contamination or process contamination was available. The authors conclude that potential exposure to 2,4,5-T or other products derived from 2,4,5-trichlorophenol exist among the workers. The cohort of workers should be included in the dioxin registry.

***Flachsbart, P.G., et al. Field Surveys of Carbon Monoxide Commercial Settings Using Personal Exposure Monitors. NTIS, Springfield, VA, EPA-600/4-84-019. Feb. 1984. PB84-211291. (NT)**

This study employed miniaturized personal exposure monitors (PEMs) to measure carbon monoxide (CO) in 588 different commercial settings (e.g., retail stores, office buildings, hotels, restaurants) in five California cities. Altogether, 5000 CO observations were made by recording the instantaneous instrument readings at 1 minute intervals as the investigators walked along sidewalks and into buildings. For 11 of 15 survey dates, two investigators walked side-by-side, permitting two adjacent PEMs to be compared. Quality assurance tests for 1706 pairs of values showed a very high degree of agreement. CO levels for indoor commercial settings were similar to those measured outdoors on sidewalks, apparently because the pollutant seeps into the structures from traffic outside. Although indoor levels usually were above 0 ppm, they seldom were above 9 ppm (the National Ambient Air Quality Standard for an 8-hour exposure), unless some indoor source (e.g., enclosed parking garage) could be identified. For example, an office building with high CO levels from its garage was "Hot" in the sense that CO permeated the upper floors, exposing many office workers to concentrations above 9 ppm, well above ambient levels outside. Indoor settings, without their own sources of CO, were sufficiently similar in concentrations to be treated as a class, although levels did vary slightly from date to date. CO levels on outdoor streets did not vary greatly on different sides of the street, on corners and faces of blocks, and intersections.

Formaldehyde. June, 1976-July, 1984 (Citations from the Energy Data Base). NTIS, Springfield, VA. July 1984. PB84-870104. (NT)

This bibliography contains citations concerning the chemical and physical properties of, and applications for, formaldehyde. The health effects of formaldehyde exposure are also considered. (This updated bibliography contains 108 citations, 24 of which are new entries to the previous edition).

Formaldehyde. June, 1970-July, 1984 (Citations from the NTIS Data Base). NTIS, Springfield, VA. July 1984. PB84-870229. (NT)

This bibliography contains citations concerning the health hazards of formaldehyde inhalation. Health hazard evaluation reports of industrial sites are discussed and the effects of formaldehyde on animals and humans are considered. Industrial hygiene sampling methods and analytical methods to quantitate formaldehyde exposure are also discussed. (This updated bibliography contains 231 citations, 48 of which are new entries to the previous edition.)

***Formaldehyde Levels in Mobile Homes. Franklin Research Center, Philadelphia, PA. NTIS, Springfield, VA, HUD-0003474. March, 1984. PB85-126571/XAB. (NT)**

A series of experiments tested the effectiveness of the following four methods for reducing levels of formaldehyde concentrations in a mobile home: normal furnace operation under thermostatic control, continuous furnace blower operation, continuous operation of the kitchen exhaust fan, and the use of a furnace modification kit. The kit introduced fresh air from the ceiling plenum, which was vented outside to the blower intake.

Two different makes of furnaces were used in identical tests. Since the mobile home's background formaldehyde level was below the discomfort level, the level was artificially raised prior to each test. The furnace modification kits for both types of furnaces reduced formaldehyde to background levels within 4 hours. Both makes of furnaces produced essentially similar levels with or without the modifications. Photographs, figures, and extensive data tables are provided.

***Gammage, R.B., et al. Current Status of Measurement Techniques and Levels of Formaldehyde in Residences. NTIS, Springfield, VA, CONF-84015-21. April 1984. DE84011660. (NT)**

For measuring levels of formaldehyde in residences, the trend is toward the increased use of passive integrating monitors. This popularity is due to ease of use, cost-effectiveness, ability to provide time-weighted-average concentrations over periods of one or more days and a sensitivity sufficient to make accurate measurements down to a few times 0.01 ppm. The more traditional modified NIOSH method lacks the sensitivity to make accurate measurements at the 0.1 ppm or lower concentrations that are encountered frequently inside houses. It is desirable that more rigorous intercomparisons of various monitoring systems be conducted, both under laboratory and field conditions. The age of urea formaldehyde-resin containing sources is a most important parameter; as the sources age they emit formaldehyde less strongly. Marked dependence of formaldehyde concentrations on age is observed for different classes of dwellings, including modern conventional houses. Levels of formaldehyde generally average about 0.03 ppm in older conventional homes. In mobile homes and a fraction of new and urea formaldehyde foam insulated (UFFI) homes, mean levels of formaldehyde frequently exceed 0.1 ppm. More systematic data are needed on the frequency and magnitude of short-term peak exposures as well as long-term seasonal variations in levels of formaldehyde. Limited studies have revealed diurnal and seasonal within-house fluctuations of two and tenfold, respectively. Occasional excursions to 0.1 ppm seem to occur in the majority of houses.

Girman, J.R., et al. Volatile Organic Emissions from Adhesives with Indoor Applications. NTIS, Springfield, VA, LBL-17594; CONF-840803-7. Feb. 1984. DE84015965/XAB. (NT)

Studies have shown that volatile organic compounds (VOC) emitted from building materials are a potentially important source of indoor air pollution. In this study, we investigated emissions of VOC from both solvent- and water-based adhesives. Adhesives were applied to an inert substrate and dried for at least a week. VOC were cryogenically trapped and identified by GC-MS or sorbent trapped, solvent extracted, and quantified by

GC-FID. Among the compounds emitted by adhesives were toluene, styrene, and a variety of normal, branched, and cyclic alkanes. The measured emission rates ranged from below the limit of detection for some adhesives to a total alkane emission rate of over 700)g/g^{-1}/h^{-1} for a water-based adhesive. A simple, well-mixed tank model was used to assess the potential impacts of the adhesives studied and to demonstrate that adhesives can be significant sources of VOC.

***Girman, J.R., et al. Sources and Concentrations of Formaldehyde in Indoor Environments. LBNL Report 14574, June 1983. 84-004239. (EN)**

Formaldehyde is a common component of resins used in many building materials. The formaldehyde can be released from these building materials into the indoor environment. Unvented combustion appliances, such as ranges and heaters, also contribute to the indoor atmospheric formaldehyde load. Emission rates from a variety of combustion appliances are discussed, and the formaldehyde concentations detected in 40 residential indoor environments are summarized. Energy-efficient houses were found to have higher concentrations of the pollutant compared with those in weatherized structures.

***Godish, T. "Low Cost Sampler for Formaldehyde and Other Indoor Air Contaminants." Journal of Environmental Health, Vol. 46, No. 5, 1984, pp. 229-232. (PA)**

Consumer requests for assistance in investigating indoor air quality complaints and provision of air testing are directed to local health agencies. Local responses to such requests are desirable since they can in general provide a quicker response than a state agency, and the minimal travel time involved results in the most efficient use of personnel time. The provision of such consumer assistance is often limited by the availability of sampling equipment. The construction of a low cost sampler for formaldehyde and other indoor air contaminants is described.

***Halpern, Marc. "Indoor/Outdoor Air Pollution Exposure Continuity Relationships." Air Pollution Control Association Journal, Vol. 28, No. 7, July 1978, p. 689. (EN)**

The relationships between indoor and outdoor pollutant concentrations and exposure continuities were evaluated using particulate leads as an index contaminant. Lead was collected using a serial filtration technique, and analyzed by atomic absorption spectrophotometry. Significant differences were observed between indoor and outdoor lead levels and between indoor and outdoor ratios of the respirable and nonrespirable lead particulates. The widely accepted hypothesis of a homeostatic balance between indoor and outdoor pollutant levels was thus refuted. It is important to consider parameters other than outdoor pollutant levels in determining indoor air quality.

***Harley, N.H. Factors Controlling Indoor Radon Levels. Annual Report, June 1983-May 1984. NTIS, Springfield, VA, DOE/EV/10374-4. May 31, 1984. DE84012712. (NT)**

The factors which contribute to indoor radon levels were investigated. Soil moisture content appears to be such a factor and influences indoor radon levels in a subtle way. The single family dwelling studied here is a typical suburban home, with a full basement, two living levels and a full attic. Seasonal data for 1981 and 1983 are shown by hour (about 90 hours in each average) for the basement, first floor and outdoors. A twenty-five story, 225 unit apartment building has been under study for about the same time interval. The apartment has five rooms, and is on the 24th floor. Continuous monitors are located in a work room and outdoors on a terrace. Data are available from the summer of 1981.

Hawthorne, A.R., et al. Formaldehyde Levels in Forty East-Tennessee Homes. NTIS, Springfield, VA, CONF-840803-12. 1984. DE84-016672/XAB. (NT)

Extensive measurements of formaldehyde levels were conducted in 40 East Tennessee homes as part of a larger indoor air quality study. Measurements were made with passive, integrating monitors for a period of 24 hours in three rooms of each house and outdoors as part of a larger indoor air quality study. Monthly measurements of this type were made in the study houses from April through mid-December of 1982. Over 6000 formaldehyde field measurements were made during the study. The measured formaldehyde concentations were generally lower in older homes. Older houses averaged 40 ppb of formaldehyde while houses less than 5 years old averaged 80 ppb. Formaldehyde levels exhibited a statistically significant temperature dependence in most homes with formaldehyde concentrations greater than 80 ppb. Homes with urea-formaldehyde foam insulation were more likely to show this relationship.

***Hawthorne, A.R., et al. Formaldehyde: An Important Indoor Pollutant. NTIS, Springfield, VA, CONF-8405169-1. 1984. DE84012331. (NT)**

Formaldehyde is an important pollutant in determining the acceptability of indoor air quality. Concern over both acute and chronic health effects have led to the desire to minimize the exposure of the public to this substance. Numerous sources exist within the indoor environment. The emission rates of many of these sources are dependent on environmental parameters. Field measurements of residential levels of formaldehyde indicate that some homes, especially mobile homes and new homes with pressed-wood materials, are frequently likely to exceed the 0.1 ppm concentration guideline. A variety of remedial measures are available to reduce formaldehyde levels. Cost and effectiveness of these measures vary. Finally, formaldehyde is but one of many volatile organic compounds that must be assessed to determine impacts on indoor air quality.

Hawthorne, A.R. Indoor Air Quality: A Researcher's Perspective. NTIS, Springfield, VA, CONF-8409155-1. 1984. DE85001251/XAB.(NT)

A brief review of some of the pollutants and the potential health effects of concern in the indoor environment are provided. Specific pollutants discussed include radon, carbon monoxide, nitrogen dioxide, smoke, asbestos, formaldehyde and biological organisms. Conservation and research needs were also discussed.

***Hileman, Bette, "Indoor Air Pollution."** Environmental Science & Technology**, Vol. 17, No. 10, Oct. 1983, p. 469A. 84-000734. (EN)**

The average concentration of pollutants typically found in indoor air has increased over the last decade. This is primarily due to decreased ventilation resulting from the implementation of residential energy conservation measures. High concentrations of radon in indoor air have been documented; building materials, soil gas, and groundwater are major pathways for this pollutant. Tobacco smoke is another indoor contaminant, as are nitrogen oxides, carbon monoxide, and particulates. A concerted interagency effort at the federal level is advocated to research this problem and devise means of correcting it.

Hollowell, Craig D. "Impact of Reduced Infiltration and Ventilation on Indoor Air Quality." ASHRAE Journal, Vol. 21, No. 7, July 1979, p. 49. (EN)

Reduced infiltration and ventilation rates in buildings, proposed as important energy conservation measures, can lead to elevated levels of indoor-generated air contaminants that may impair the health, safety, or comfort of occupants. Nitrogen dioxide, formaldehyde, and radon, three indoor-generated contaminants of particular concern in residential buildings, are discussed. Possible regulatory approaches for limiting exposure to indoor contaminants are mentioned.

Indoor Air Pollution. January, 1983 - October, 1983 (Citations from the Energy Data Base). NTIS, Springfield, VA. Oct. 1984. PB84-876812. (NT)

The bibliography contains citations concerning the types and sources of indoor air pollution, the impact of energy efficient construction, and measures to relieve the problem. Radon and radon-daughters, nitrogen oxide, carbon monoxide, asbestos, formaldehyde, and particulates are discussed as potential pollutants, and recirculated air, insulation material, water, and natural gas are considered as potential sources of pollution. Mechanical ventilation systems with air to air exchangers are briefly discussed.

Indoor Air Pollution. November, 1983 - October, 1984 (Citations from the Energy Data Base)." NTIS, Springfield, VA. Oct. 1984. PB84-876820. (NT)

This bibliography contains citations concerning the types and sources of indoor air pollution, the impact of energy efficient construction, and measures to relieve the problem. Radon and radon-daughters, nitrogen oxide, carbon monoxide, asbestos, formaldehyde, and particulates are discussed as potential pollutants, and recirculated air, insulation material, water and natural gas are considered as potential sources of pollution. Mechanical ventilation systems with air to air exchangers are briefly discussed.

***"Indoor Air Quality Research." House Committee on Science and Technology Hearings, 98 Con 1 54, Aug 2-3, 1983. 84-004249. (EN)**

Indoor air quality has become a major concern since the discovery that energy-efficient houses, with reduced air infiltration, may have higher concentrations of pollutants. Since most people spend up to 90% of their time indoors, this could be a significant health hazard. Hearings were held to discuss various issues, including indoor air contaminants and characteristics, observed concentrations, personal exposure to contaminants, health effects, and control of indoor contaminants. Contaminants include formaldehyde, radon, molds, spores, fungi, aeropathogens, asbestos fibers, chlordane and other insecticides, house mites, photocopying solvents, and tobacco smoke. Ironically, millions have been spent to improve outdoor air quality, while indoor air quality has been widely ignored. Associated documents and memoranda are transcribed.

Janssen, F.J.G. "Measurements at the Sub-ppm Level of Sulphur-Fluoride Compounds Resulting from the Decomposition of SF_6 by Arc Discharge." NTIS, Springfield, VA, PB84-213412, 1984. (NT)

Arcing experiments from sulphur hexafluoride have shown reactions between SF_6, moisture, oxygen and metals; various compounds were formed, namely SF_4, SOF_2, SOF_4, SO_2F_2, S_2F_{10}, HF, SO_2, H_2S and S_2OF_{10}. Some of these compounds appeared in very low concentrations. The compounds are toxic even at these levels of concentration and they show corrosive properties; so it is important to identify them and to determine the quantities of these arcing products. Gas chromatography and mass spectrometry have proved to be relevant tools for the trace analysis of disulphur decafluoride and disulphur oxydecafluoride.

***Jungers, R.H., et al. "Exposure to Perchloroethylene Associated with the use of Coin-type Dry Cleaning Machines." EPA Pollutant Monitoring of Ambient Air and Stationary Sources Symposium, Raleigh, NC. May 1982, p. 153. 84-002969. (EN)**

Nearly all coin-type dry cleaners use perchloroethylene (PERC) as the cleaning solvent. Research was sponsored by EPA to obtain data demonstrating the potential for public exposure to PERC that may result from dry cleaning in these self-service laundries. Testing at a laundry facility and at an overhead apartment was conducted in Washington, D.C. Indoor ambient PERC levels varied in the range of 90-14,000 ppb. PERC levels in the apartment were practically identical to those in the laundry downstairs.

***Kirsch, Laurence S. "Behind Closed Doors: The Problem of Indoor Pollutants." Environment, March 1983, Vol. 25, No. 2, p. 16. 83-004368. (EN)**

Health hazards associated with indoor air pollution are examined. The indoor air pollutants currently under scrutiny include radon and its decay products, chemical products of combustion (such as nitrogen oxides and carbon monoxide), formaldehyde, asbestos, residues from consumer products, allergens, microorganisms, and tobacco smoke. These pollutants cause respiratory diseases, cancer and sometimes death. Since they are more concentrated indoors, current statutory and common law mechanisms for dealing with indoor air pollution are inadequate.

***Kothari, Brajesh K., et al. "Association of Indoor Radon Concentration and Uranium in Surficial Material." Northeastern Environmental Science, Vol. 3, No. 1, 1984, p. 30. 84-005955. (EN)**

Exposure to radon in the indoor environment of homes averages 0.2-4 PCI/L. Radon data for houses with identified sources of the radionuclide are analyzed for available data from nine locations. The geometric means of equivalent uranium data from the National Uranium Resource Evaluation Survey for the same sites correlate with the percentage of homes with radon levels above a desired limit. This provides a basis for identifying areas in the U.S. where high values of indoor radon might be found for further investigation. (EN)

***Leidy, R. B., et al. "Concentration and Movement of Diazinon in Air." Journal of Environmental Sciences & Health-Pesticides, Food Contaminants & Agricultural Wastes, Vol. B17, No. 4, 1982, p. 311. 82-005539. (EN)**

Airborne concentrations of diazinon were measured in rooms for 21 days after crack and crevice application. Treated rooms had residue levels of 38 mg/m^3, adjacent rooms had levels of 1 mg/m^3. Low levels of diazinon were detected in all rooms 21 days after application; small amounts of the residues were found on respirator pads and waist pads worn by the applicator. Data indicated no serious hazard to an individual from the prescribed diazinon application rate.

***Livingston, J. M., et al. "Living Area Contamination by Chlordane Used for Termite Treatment." Bulletin of Environmental Contaminants and Toxicology, Vol. 27, No. 3, September 1981, p. 406. (EN)**

Chlordane contamination in living areas at a midwestern U.S. Air Force Base was monitored. The contamination resulted from chlordane treatments for termite control. Airborne chlordane concentrations recorded were in the range of 16-293 mg/m^3. Air sampling data from 1964-79 are tabulated and compared.

***Londhe, V. S., et al. "Assessment of Natural Radioactivity Levels in Building Materials and Evaluation of Indoor Radon Exposure." Environmental Technology Letters, Vol. 5, No. 2, February 1984, p. 81. 84-004610. (EN)**

Natural radioactivity levels were tested for building materials used in some cement houses in Bombay, India, and nearby areas. Exposure to natural radiation is comparatively higher in cement houses than in wooden or brick houses. One to two kg samples were collected from construction sites and from local dealers in Bombay. Granite samples were collected from surrounding quarries. The study presents estimations of natural radioelements like Radon-222, Thorium-222, and Potassium-40 in a limited number of samples of building materials used in Bombay. Quantities of cement, sand, bricks, and stones required for model room were calculated from the standard construction data.

***Matsukuru, Shiegeru, et al. "Effects of Environmental Tobacco Smoke on Urinary Cotinine Excretion in Nonsmokers." New England Journal of Medicine, Vol. 311, No. 13, September 1984, p. 828. 84-006296. (EN)**

The relationship between urinary cotinine (the major metabolite of nicotine found in urine) excretion in 472 nonsmokers and the smokiness of their environment is investigated. Urinary cotinine levels of nonsmokers who lived with smokers were higher than those of nonsmokers who did not. These levels increased with the combined daily cigarette consumption of smokers in the family. Urinary cotinine values of nonsmokers who worked with smokers were also higher than those of nonsmokers who did not. These values increased with the number of smokers in the workroom. The presence of smokers in both the home and workplace also increased the cotinine levels, and urban nonsmokers had more cotinine in their urine than did rural smokers. The deleterious effects of passive nonsmoking may occur in proportion to the exposure of nonsmokers to the home, workplace, and community.

Matthews, T. G., et al. Practical Measurement Technology for Low-Formaldehyde-Concentration Levels: Applications to Personnel-Monitoring Needs. Oak Ridge National Laboratory, TN, EPA National Symposium on Monitoring Hazardous Organic Pollutants in Air, Raleigh, NC. May 1, 1984. (PA)

A formaldehyde (CH_2O) monitoring program has been developed at Oak Ridge National Laboratory to assist the Consumer Product Safety Commission in its deliberations concerning the use of urea-formaldehyde foam insulation materials and the possible development of an indoor air quality standard for formaldehyde. Low-cost monitoring technology for a large-scale screening analysis of CH_2O levels in domestic dwellings and near real-time instrumentation for inspectorate purposes has been developed. The applicability of the new methodologies to personnel monitoring needs, including area monitors, personnel badges, and near real-time measurement techniques, is now under investigation.

***Matthews, T. G., et al. Formaldehyde Emissions from Combustion Sources and Solid Formaldehyde Resin Containing Products: Potential Impact on Indoor Formaldehyde Concentrations. NTIS, Springfield, VA, CONF-840415-22. April 12, 1984. DE84011630. (NT)**

The formaldehyde (CH_2O) emission rates of combustion sources and solid CH_2O resin-containing products commonly found in domestic environments are surveyed. The potential impact of these sources on indoor CH_2O concentrations are estimated using simple steady-state, indoor pollutant concentration models. Source emission rates, product loadings for solid emission sources, duty cycles for combustion sources, and potential permeation barriers are considered in the model. The strongest contributors to indoor CH_2O are pressed-wood products and foam insulation containing urea formaldehyde resins. Combustion sources and phenol-formaldehyde resin-bonded products are generally weak emitters.

***Matthews, T. G., et al. "Visual Colorimetric Formaldehyde Screening Analysis for Indoor Air." Air Pollution Control Association Journal, Vol. 31, No. 11, November 1981, p. 1181. 82-003376. (EN)**

A visual colorimetric analysis method for screening formaldehyde levels at about 100 ppb concentration is demonstrated. The method, based on the general aldehyde methylbenzothiazolin-hydrazone technique, is insensitive to variations of 15% in reagent concentration and ambient temperatures between 14-26°C. Field tests show that the method is well suited for screening formaldehyde levels in homes.

Matthews, T. G., et al. "Environmental Dependence of Formaldehyde Emission from Pressed-Wood Products." NTIS, Springfield, VA, CONF-840803-10. 1984. DE84016593/XAB. (NT)

The influence of temperature, humidity and formaldehyde (CH_2O) vapor concentration on CH_2O emissions from low emitting particleboard underlayment and hardwood plywood paneling bonded with urea-formaldehyde resins have been examined using environmental chamber experiments. A 10- to 30-fold increase in CH_2O emissions was observed over the tested range of temperature and humidity conditions from 23°C, 50% RH to 38°C, 68% RH. A CH_2O emission model has been developed from simple diffusion theory applied to the bulk-vapor interphase at the surface of pressed-wood products to evaluate the dependence of CH_2O emissions from the test boards on ambient conditions. Significant variation is observed in the model coefficients for temperature and humidity between different products.

Matthews, T. G., et al. "Formaldehyde Emissions from Consumer and Construction Products: Potential Impact on Indoor Formaldehyde Concentrations." NTIS Springfield, VA, CONF-840803-9. 1984. DE84016592/XAB. (NT)

The formaldehyde (CH_2O) emission rates of combustion sources and solid CH_2O resin-containing products commonly found in domestic environments are surveyed. The potential impact of these emitters on indoor CH_2O concentrations are estimated using simply steady-state, indoor pollutant concentration models. The strongest contributors to indoor CH_2O are pressed-wood products and foam insulation containing urea-formaldehyde resins.

Combustion sources and products containing phenol-formaldehyde resins are generally weak steady-state emitters.

***Melia, R.J.W., et al. "Differences in NO_2 Levels in Kitchens with Gas or Electric Cookers." Atmospheric Environment, Vol. 12, No. 6-7, 1978, p. 1379. (EN)**

The reliability of a small personal sampler for nitrogen dioxide measurements is tested. Levels measured in kitchens with gas and electric cookers are contrasted. The higher concentration of NO_2 in gas kitchens, if maintained, would lead to levels above the maximum annual arithmetic mean of 50 PPB recommended in the U.S. primary air quality standards.

***Milligan, J. E., et al. "A Study of Nitrous Oxide Levels in Veterinary Operating Room Air With and Without Waste Anesthetic Gas Scavenging." University of Missouri Trace Substances in Environmental Health 15th Annual Conference, June 1981, p. 399. 83-001460. (EN)**

Long-term human exposure to nitrous oxide is associated with general health problems, including reproductive difficulties and kidney and liver diseases. A study to assess the exposure levels to nitrous oxide in veterinary surgery was performed during scavenging and not scavenging of the waste anesthetic gas. While the 95% upper confidence limit for the scavenged mean was within the NIOSH standard, the 95% upper confidence limit for the not scavenged mean exceeded the standard.

***Moed, B. A., et al. Identifying Areas with Potential for High Indoor Radon Levels: Analysis of the National Airborne Radiometric Reconnaissance Data for California and the Pacific Northwest." LBNL Report 16955, April 1984. 84-006646 (EN)**

Aerial radiometric data collected for the National Uranium Resource Evaluation Program are analyzed for seven western U.S. states in order to provide information on the spatial distribution of radium contents in surficial geologic materials, and to identify areas where high indoor radon levels may be common. Results show a range of mean radium concentrations averaged over geologic map units of 0.1-3.6 PCI G-1, with an overall mean for the study area of 0.7 PCI G-1. Radium concentrations were found to be relatively low in central and western portions of Washington, Oregon, and Northern California. They were relatively high in Central and Southern California. A field validation study near Spokane, Washington, showed close correspondence between the aerial data, in situ measurements of both radium content and radon flux from soil, and laboratory measurements of both radium content and radon emanation rate from soil samples.

***Morse, S.S., et al. Indoor-Outdoor Pollution Levels: A Bibliography Interim Report. NTIS, Springfield, VA, March 1979. EPRI-EA-1025. (NT)**

This annotated bibliography covers literature on the subject of indoor and outdoor pollution levels. Specifically, the works cited are those which have a bearing on the EPRI-supported study comparison of indoor and outdoor concentrations of atmospheric pollutants. The bibliography is not exhaustive. It contains primarily available publications and research reports which are relevant to the specific objectives of the EPRI-GEOMET Project: Indoor sources of pollutants, behavior of indoor pollutants, indoor-outdoor relationships, and health effects. It does not cover construction or conservation measures which have an effect on indoor pollutant concentrations. Because the EPRI-GEOMET research involves a study of air quality in residences and offices, the literature review for this bibliography focused on those two environments. All papers which are listed were obtained and reviewed. Subject and author indices appear at the end of the bibliography for purposes of cross-referencing.

***Moschandreas, Demetrios J., et al. "The Effects of Woodburning on the Indoor Residential Air Quality." Environment International, Vol. 4, Nos. 5 & 6, 1980, p. 463. 81-006204. (EN)**

The upward trend in residential woodstove use inspired an investigation assessing the effects of woodstove burning on indoor air quality. The indoor and outdoor air pollution of ten residences and two office buildings were compared; three of these residences used either a woodstove or a fireplace. Monitoring lasted two weeks at each residence, was conducted under real-life conditions and indicated that indoor total suspended particulate (TSP) concentrations during woodburning were about three times corresponding levels during nonwoodburning periods. Elevated indoor concentrations of TSP, respirable particulates, and benzo-a-pyrene were attributed to woodburning.

***Moschandreas, D. J., et al. "Fine Particle Residential Indoor Air Pollution." Atmospheric Environment, 1979, pp. 1413-1418. (PA)**

Indoor-generated elemental constituents of fine aerosol particulate matter may be distinguished from constituents infiltrating from the outdoors by comparing time variation in concentrations hourly. Measurements within 3 residential buildings indicate that sulfur and lead-bromine aerosols are predominantly of outdoor origin, although a secondary indoor lead source was detected. Potassium is, to a significant degree, of indoor origin. Indoor-outdoor exchange times inferred for fine particulate constituents agree with those estimated for gas exchange and with model calculations, suggesting conservative fine aerosol transport. However, coarse particle constituents, e.g., iron, exhibit time variability complicated by nonconservative behavior, such as removal by filtration and settling.

Narasaki, M. "Control of Indoor Air Pollution Due to Smoking." Japan Air Cleaning Association Journal, Vol. 4, No. 4, November 1976, p. 12. (EN)

Indoor air pollution due to cigarette smoking is assessed. Emphasis is on suspended dust concentration. The amount of pollutants generated by smoking depends on existing smoking conditions and is the same at all times, regardless of the frequency and velocity of puffing, as long as the number of cigarettes smoked remains the same. Increased suspended dust concentration in an office is estimated.

***Nasralla, M. M. "Studies on Indoor Air Quality in Egypt." Environment International, Vol. 4, Nos. 5 & 6, 1980, pp. 469-473. (PA)**

Indoor air quality was examined for some gaseous pollutants and particulate matters. In a public library, the indoor/outdoor ratio of gaseous pollutants was found to be dependent on their reactivity, the outdoor concentrations, and weather conditions. This ratio was 0.6 for SO_2 and 1.3 for CO. The indoor/outdoor ratio of carbon monoxide was found to increase at the higher floors of the same building. Concentrations of indoor particulates was found to be influenced by the outdoor concentrations and the particle size. Analysis indicated that indoor suspended dust contained a significant high concentration of lead as compared with outdoor values. Indoor sources were found to pollute the premises of fossil-fuel equipped homes, thus having carbon monoxide concentrations more than the recognized threshold limit value for industry.

***Nazaroff, W. W., *et al*. "Radon Entry Into Houses Having a Crawl Space." LBNL Report 16637, December 1983. 84-005956. (EN)**

Houses containing typical amounts of radon flux from the soil were studied. Radon flux from the crawl space entered the living space. Sealing crawl space vents may increase indoor radon concentrations. Radon reduction might be achieved by sealing floor leaks. A polyethylene ground sheet did not reduce influx in the one case studied.

Nazaroff, W. W., et al. Transport of Radon from Soil into Residences. NTIS, Springfield, VA, LBL-16823, CONF-840803-4. February 1984. DE84015996/XAB. (NT)

To develop effective monitoring and control programs for indoor radon it is important to understand the causes of the broad range of concentrations that has been observed. Measurements of indoor radon concentration and air-exchange rate in dwellings in several countries indicate that this variability arises largely from differences among structures in the rate of radon entry. Recent evidence further suggests that the major source of indoor radon in many circumstances is the soil adjacent to the building foundation and that pressure-driven flow, rather than molecular diffusion, is the dominant transport process by which radon enters the buildings. Key factors affecting radon transport from soil are radon production in soil, flow-inducing mechanisms, soil permeability, and building substructure type.

Oak Ridge National Laboratory. Indoor Air and Human Health: Major Indoor Air Pollutants and Their Health Implications. NTIS, Springfield, VA, CONF-8410136-ABSTS. 1984. DE85001081/XAB. (NT)

This publication is a collection of abstracts of papers presented at the Indoor Air and Human Health symposium. Session titles include: Radon, Microorganisms, Passive Cigarette Smoke, Combustion Products, Organics, and Panel and Audience Discussion.

***O'Brien, D.M., et al. Control Technology for New Plastics Processes at Air Plastics, Inc., Cincinnati, Ohio. National Institute for Occupational Safety and Health, Cincinnati, OH. Engineering and Control Technology Branch. NTIS, Springfield, VA, CT-148-15. June 1984. PB84-241678. (NT)**

Area and breathing zone samples were analyzed for styrene (100425) at Air Plastics, Incorporated (SIC-3079), Cincinnati, Ohio, in June 1984. Engineering controls and work practices in the filament winding process were investigated. The workers positioned themselves upwind of the product during spraying and roll out. This had been determined to be the best position for avoiding back spray during the operation. The company had purchased detector tube kits for monitoring styrene exposure. Employees in the spray and roll out operations wore protective goggles and half mask respirators. Employees in fiberglass cutting and grinding operations wore nuisance dust respirators. The authors recommend installation of an oil free compressor as a source of breathing air and installation of partitions around each winding mandrel.

***O'Brien, D., et al. Control Technology for New Plastic Processes at Ford Motor Company, Saline Instrument and Plastics Plant, Saline, Michigan. National Institute for Occupation Safety and Health, Cincinnati, OH. Engineering and Control Technology Branch. NTIS, Springfield, VA, CT-148-12. February 1984. PB84-241900. (NT)**

A walk through survey of the instrument panel molding operations at Ford Motor Company (SIC-3711), Saline, Michigan was conducted to familiarize investigators with the reaction injection molding process, to help them to understand the potential during the operations for exposure to air contaminants, and to observe control measures employed. The major hazard associated with the process was exposure to isocyanates, specifically, diphenylmethanediisocyanate (101688) (MDI). NIOSH recommended ceiling concentrations for MDI were 20 parts per billion (ppb), but a standard of 2 ppb was maintained by the company. Other potential exposures included mold release agents. The process was a closed system. Fresh air was supplied to all work areas. An effective system was developed for potential exposures due to system malfunction. The author concludes that evaluation of the working environment using an improved sampling and analysis technique for total isocyanates should be considered.

***Offerman, F. J., et al. "Control of Respirable Particles and Radon Progeny with Portable Air Cleaners." NTIS, Springfield, VA, LBL-16659. February 1984. DE84013878. (NT)**

Eleven portable air cleaning devices have been evaluated for control of indoor air concentrations of respirable particles and radon progeny. Following injection of cigarette smoke and radon in a room-size chamber, decay rates for particles and radon progeny concentrations were measured with and without air cleaner operation. Particle concentrations were obtained for total number concentration and for number concentration by particle size. In tests with no air cleaner the natural decay rate for cigarette smoke was observed to be 0.2 hr^{-1}. Air cleaning rates for particles were found to be negligible for several small panel-filters, a residential ion-generator, and a pair of mixing fans. The electrostatic precipitators and extended surface filters tests have significant particle removal rates, and a HEPA-type filter was the most efficient air cleaner. The evaluation of radon progeny control produced similar results; the air cleaners which were effective in removing particles were also effective in removing radon progeny. At low particle concentrations plateout of the unattached radon progeny is an important removal mechanism. Based on data from these tests, the plateout rate for unattached progeny was found to be 15 hr^{-1}. The unattached fraction and the overall removal rate due to deposition of attached and unattached nuclides have been estimated for each radon decay product as a function of particle concentration. While air cleaning can be effective in reducing total radon progeny concentrations of unattached radon progeny can increase with increasing air cleaning.

Offerman, F. J., et al. "Controlling Indoor Air Pollution from Tobacco Smoke: Models and Measurements." NTIS, Springfield, VA, LBL-17603, CONF-840803-16. July 1984. DE84016888/XAB. (NT)

The effects of smoking rate, ventilation, surface deposition, and air cleaning on the indoor concentrations of respirable particulate matter and carbon monoxide generated by cigarette smoke are examined. A general mass balance model is presented which has been extended to include the concept of ventilation efficiency. Following a review of the source and removal terms associated with respirable particles and carbon monoxide, the model's predictions are compared to various health guidelines.

***Oswald, R. A., et al. "Indoor Air Pollution: The Experience with Radon." ISES/Solar Energy Society of Canada Energex 8th Conference, Regina, Canada, Vol. 1, August 1982, p. 46. 84-003994. (EN)**

Concern has been expressed about the increasing risks of lung cancer associated with elevated indoor levels of radon. The principal source of indoor radon is radium in underlying soils and rocks and in building materials. Indoor concentrations of this radioisotope can increase as a result of energy conservation measures which reduce air infiltration and ventilation. Track etch detectors have been used to measure radon levels in homes in Canada, U.S. and Sweden. Indoor exposure rates in some areas have been found to exceed 20 pci/l.

***Pellizzari, E. D., et al. "Human Exposure to Vapor-Phase Halogenated Hydrocarbons: Fixed-site vs. Personal Exposure." EPA Monitoring of Ambient Air & Stationary Sources Symposium, Raleigh, NC, May 1982, p. 264 84-002970. (EN)**

The use of personal and fixed-station monitoring for assessing exposure of populations to halocarbons is discussed. Atmospheric exposure to volatile halogenated hydrocarbons was studied in populations in two geographic areas, Baton Rouge, LA, and Greensboro, NC. The relative merits and limitations of fixed-station monitoring systems and personal monitors are addressed. Air sampling values are reported for diverse chlorinated hydrocarbons. The levels of halocarbons in personal air samples were higher than fixed-site samples.

***Pengelly, L.D., _et al_. "The Hamilton Study: Relationship Between Outdoor and Indoor Air Quality in Homes and Elementary Schools." _Canada Ministry of Environment General and Air Pollution Research Technology Transfer Conference_, Toronto. Vol. 1, November 1983, p. 184. 84-006328 (EN)**

Measurements were made of indoor and outdoor levels of nitrogen dioxide, sulfur dioxide, and particulates in Hamilton, Ontario Province, residences and schools. Observations were made for two five-day sessions at each site, once during the heating season and once during non-heating periods. For NO_2, the indoor/outdoor ratio was close to 75% in schools and was independent of heating season; indoor levels were strongly correlated with outdoor concentrations. In homes, the indoor ratio strongly depended on the presence of indoor sources such as stoves. In the absence of these, little effect of heating season was documented and the ratio was about 80%. Indoor levels of SO_2 were also correlated with outdoor levels at all sites.

***Pickrell, John A., _et al_. "Formaldehyde Release Rate Coefficients from Selected Consumer Products." _Environmental Science and Technology_, Vol. 127, December 1983, No. 12, p. 753. 84-002122. (EN)**

Many consumer products release formaldehyde into the atmosphere in varying concentrations. A modification of the Japanese Industrial Standard Desiccator Test was used to measure formaldehyde release from six different types of consumer products for 46 samples after conditioning. The products sampled were pressed wood, clothes, insulation, paper, fabric, and carpet. The eight highest release coefficients were from pressed wood samples. More than half of the products had release coefficients that were less than or equal to 100 mg of formaldehyde released per day.

Polymeric Materials Combustion: Toxicity Hazards and Legal Aspects (Citations from the Rubber and Plastic Research Association Data Base). National Technical Information Service, Springfield, VA. July 1984. PB84-871342. (NT)

This bibliography contains citations concerning the toxicity hazards from, and the legal aspects of, polymeric materials combustion in building, electrical and electronic applications. Flammability assessment, flame retardant additives, and toxicity standards for polymeric materials are discussed. Regulations and legislation on polymer flammability are included. Health hazards caused by toxic gases from polymeric materials combustion are considered. (This updated bibliography contains 119 citations, 30 of which are new entries to the previous edition.)

***Reif, Arnold E. "The Indoor Environment: The Environmentalist's Stepchild?" Environmental Action, Vol. 8, No. 19, September 1977, p. 4. 78-002845. (EN)**

Sources of indoor air pollution are identified. Suspended dust particles and gases from coal furnaces, gas stoves, and cars driven into a garage are indoor air pollutants. Pollution released from cigarette smoke is examined: mainstream and sidestream smoke; nicotine; and carbon monoxide. Carcinogenic agents active in the act of inhaling cigarette smoke and found in atmospheric pollution are discussed.

***Reisdorf, R. P., et al. Survey of Health Hazard Control Systems for Mercury Use and Processing. National Institute for Occupational Safety and Health, Cincinnati, OH. NTIS, Springfield, VA, February 1984. PB85-107241/XAB. (NT)**

Surveys of systems for the control of health hazards arising from the use and processing of mercury (7439976) were conducted during 28 site visits to 24 facilities. These facilities included manufacturers of batteries, thermometers, fluorescent lamps and electrical switches, chemical processing and production operations, and dental clinics. The control of worker exposure to mercury at all the facilities, except the dental clinics, was the result of an integrated control approach that included engineering controls, personal protection, and monitoring programs. In these operations, full time use of respirators is recommended until appropriate control measures are instituted.

***Repace, James L., et al. "Indoor Air Pollution, Tobacco Smoke, and Public Health." Science, Vol. 208, No. 4443, May 1980, p. 464. 80-004164. (EN)**

Research that assessed the health hazards to nonsmokers posed by exposure to tobacco smoke in buildings is described. A model that incorporates both physical and sociological parameters in determining the levels of respirable suspended particulates in tobacco smoke is developed. Results indicate that nonsmokers are exposed to significant air pollution burdens from indoor smoking. The public health implications of this exposure is assessed.

Revzan, K. L. Effectiveness of Local Ventilation in Removing Simulated Pollution from Point Sources. NTIS, Springfield, VA, LBL-17601, CONF-840803-1. February 1984. DE84016053. (NT)

The effectiveness of range hoods and window fans in removing indoor pollutants is considered. Tests were conducted in a two-room tent space with an air filtration rate less than 0.1 hr^{-1} using sulfur hexafluoride as a tracer gas. Range hood tests were carried out with heated and unheated tracer gas. In the former case, ventilation efficiency was roughly linear over a range of flow rates from 10.3 to 60.0 l/sec., the highest measured efficiency being 0.77. With unheated tracer gas, effectiveness was highly dependent on environmental conditions. Window fan tests were conducted with the source of tracer gas in each of the two rooms, the fan itself remaining fixed. With the source in the room without the fan, fairly good agreement with a mass-balance model was obtained. With the source in the same room as the fan, agreement with the model was poor. In all cases, the results suggest the importance of free convection in pollutant transport.

***Rivers, R. D. "Predicting Particulate Air Quality in Recirculatory Ventilation Systems." ASHRAE Semiannual Symposium, Houston, January 1982, p. 929. 83-004949. (EN)**

Systems parameters such as airflow rates, internal contaminant generation rates, outdoor air quality and filter efficiency are used to predict indoor air quality. This paper attempts to supply reasonable values to these parameters. Additionally, a calculation scheme applicable to a wide range of system configurations and operating conditions is presented. Two general types of systems are considered: one with no parallel flows and those with parallel airflows and multiple zones. Mass balance equations are provided for both. Other factors considered in the predictive calculations of air quality are particle size distributions, outdoor dust concentrations, and vertical distribution of dust concentrations. Penetration vs. particle diameter for air cleaners and dust loading characteristics of air cleaners are examined briefly.

***Sebastien, P., et al. "Indoor Airborne Asbestos Pollution: From the Ceiling and the Floor." Science, Vol. 216, No. 4553, June 1982, p. 1410. 82-005560. (EN)**

Asbestos contamination of an office-building containing ceilings sprayed with crocidolite material and floors with vinyl-chrysotile tiles was studied through the implementation of electron microscope measurements. This was the first measurement of elevated levels of asbestos in the building. The elevated measurements were associated with the weathering of the asbestos floor tiles.

***Seifert, B., et al. "Indoor Air Concentrations of Benzene and Some other Aromatic Hydrocarbons." Ecotoxicology and Environmental Safety, Vol. 6, 1982, p. 190. 83-000034. (EN)**

Reasons for the presence of contaminants in indoor environments include: frequent burning processes, such as smoking; use of consumer products; and toxic emanation from building materials. Indoor concentrations of benzene and other aromatic hydrocarbons were studied. Sampling was conducted with a passive sampler and charcoal pad.

Sextro, R.C., et al. Evaluation of Indoor Aerosol Control Devices and Their Effects on Radon Progeny Concentrations. California University, Berkeley, Lawrence Berkeley Laboratory. NTIS, Springfield, VA, LBL-17598, CONF-840803-8. February 1984. DE84016001/XAB. (NT)

Eleven portable air cleaning devices have been evaluated for control of indoor concentrations of respirable particles, and their concomitant effects on radon progeny concentrations have been investigated. Of the devices we examined the electrostatic precipitators and extended surface filters had significant particle removal rates, while the particle removel rates for several small panel-filters, an ion-generator, and a pair of mixing fans were found to be negligible. The evaluation of radon progeny control produced similar results; the air cleaners which were effective in removing particles were also effective in reducing radon progeny concentraitons. Furthermore, at the low particle concentrations, plateout of the unattached radon progeny was found to be a significant removal mechanism. The overall removal rates due to deposition of attached and unattached progeny have been estimated from these data, and the equilibrium factors for total and unattached progeny concentrations have been calculated as a function of particle concentration.

***Shepard, Roy J., et al. "Interaction of Ozone and Cigarette Smoke Exposure." Environmental Research, Vol. 31, No. 1, June 1983, p. 125. 84-000712. (EN)**

To simulate the effects of indoor air pollution combined with cigarette smoke on humans, chamber exposures to ozone are carried out on human subjects who are smokers. O_3 levels are increased progressively over four trials, and exercise is induced to increase ventilation. O_3 exposure reduces the carbon monoxide intake normally seen with smoking. No appreciable interaction between responses to O_3 and cigarette smoking is demonstrated.

***Smith, Kirk R., et al. "Air Pollution and Rural Biomass Fuels in Developing Countries: A Pilot Village Study in India and Implications for Research and Policy." Atmospheric Environment, Vol. 17, No. 11, 1983, p. 2343. 84-006276. (EN)**

Personal exposures to total suspended particulates and benzo-a-pyrene in four rural Indian villages were measured in 1981. Pollutant levels were measured indoors as a function of biomass fuel and type of cooking stove used. Various stove types, cooking times, family sizes, and income levels were considered; firewood and agricultural wastes were the biofuels of interest. Particulate exposures averaged nearly 7 mg/m^3 and benzo-a-pyrene about 400 ng/m^3 during the cooking period, which occupied about 10% of the year. Factors affecting indoor air pollution exposures in rural areas of developing nations are discussed with reference to published field data. The paucity of related information reveals many issues requiring future research. Fuel use and combustion conditions, pollutant emission rates, and other factors must be addressed.

***Smith, Lawrence R. "Nitrosamines in Vehicle Interiors." NTIS, Springfield, VA, PB82-125014, September 1981. 82-004736. (EN)**

Views of researchers in the nitrosamine field concerning the tea analyzer and the thermosorb/n air samplers for nitrosamine analysis are presented. Gas samples are taken from vehicle interiors to determine the effects of vehicle type, vehicle age, mode of operation, and ambient conditions on interior nitrosamine levels. A total of 58 vehicles are sampled and occupant exposure levels are estimated using test vehicle data.

***Spengler, John D., Duffy, Colin P., _et al_. "Nitrogen Dioxide Inside and Outside 137 Homes and Implications for Ambient Air Quality Standards and Health Effects Research." _Environmental Science & Technology_, Vol. 17, No. 3, March 1983, p. 164. 83-005520. (EN)**

Integrated nitrogen dioxide measurements were taken by diffusion tube samplers inside and outside 137 homes in Portage, WI. Over a one-year period, the annual mean ambient NO_2 concentrations were 10-15 mg/m^3. NO_2 levels inside the kitchens of 112 homes with gas stoves averaged 50 mg/m^3 higher, and bedroom levels were about 30 mg/m^3 higher than outdoor levels. Ten percent of gas cooking homes had annual average kitchen NO_2 levels higher than the national ambient air quality standard of 100 mg/m^3. NO_2 levels inside the kitchens of 25 homes with electric stoves were two-thirds outdoor levels, and bedroom levels were one-half outdoor levels. The variation of NO_2 levels among homes due to differences in stove use, emission rates, and air exchange rates impedes the development of prediction models.

***Stone, Robert, _et al_. _Evaluation of Formaldehyde in Residential Mobile Homes_. NTIS, Springfield, VA, PB82-144619, March 1981, 82-006237. (EN)**

The extent of formaldehyde contamination inside residential mobile homes is investigated. A computer model is developed to aid HUD in evaluating potential alternatives for regulating maximum formaldehyde levels for new mobile homes. Health costs associated with formaldehyde exposure are examined to establish baseline costs incurred by mobile home occupants in the absence of regulation.

Strenio, J., et al. Asbestos in Buildings: A National Survey of Asbestos-Containing Friable Materials. **NTIS, Springfield, VA, EPA/560/5-84/006, October 1984. PB85-136653/XAB. (NT)**

A nationally representative sample of 231 buildings at 10 sites were inspected for potentially asbestos-containing materials. Bulk samples (1,510) were taken and analyzed by Polarized Light Microscopy. Estimates were made of the number and percent of buildings with asbestos-containing friable materials, the square footage of such materials, and the percent asbestos content of the materials. In buildings constructed prior to 1960, ACFM was concentrated primarily in pipe and boiler insulation; in buildings constructed between 1960 and the early 1970s, ACFM was concentrated primarily in sprayed-on or trowelled-on materials. In 1973, EPA banned the use of asbestos thermal and acoustical insulation materials except for decorative purposes, and in 1978 EPA banned them for all purposes.

Styrenes: Industrial Health Hazards. 1977-July, 1984 (Citations from the Rubber and Plastics Research Association Data Base). NTIS, Springfield, VA, August 1984. PB84-872282. (NT)

This bibliography contains citations concerning the effects of styrene toxins on workforces in industrial plastic manufacturing and processing. Occupational hygiene, pharmacokinetics, pharmacodynamics, biotransformation, mutagenesis, teratogenesis, carcinogenesis, neurotoxicity and fatality rates of exposed workers are also included. Occupational health and safety regulations and legislation are also discussed.

Swedish Council for Building Research. Indoor Air. Volume 2. Radon, Passive Smoking, Particulates and Housing Epidemiology. Proceedings of the International Conference (3rd) on Indoor Air Quality and Climate Held in Stockholm on August 20-24, 1984. NTIS, Springfield, VA, ISBN-91-540-4193-7, 1984, PB85-104198/XAB. (NT)

Contents: Radon in dwellings, exposure and risk analysis, sources and measurements. Fibres and particulates in the indoor environment, characterization and risks. Epidemiological studies of health disorders related to housing, and passive smoking and health effects, characterization and countermeasures.

Swedish Council for Building Research. Indoor Air. Volume 4. Chemical Characterization and Personal Exposure. Proceedings of the International Conference (3rd) on Indoor Air Quality and Climate Held in Stockholm on August 20-24, 1984. **NTIS, Springfield, VA, ISBN-91-540-4199-6, 1984. PB85-104214/XAB. (NT)**

Contents: Characterization of indoor gaseous pollutants, sources and emission rates, sampling and analytical methods. Indoor/outdoor relationships, i.e. nitrogen oxides and carbon monoxide, and importance of indoor air pollution to personal exposure in industrialized and developing societies.

Traynor, G.W. "Indoor Air Quality: Potential Audit Strategies." Annual Energy Conservation Management Conference, Portland, Oregon, March 1981. **NTIS, Springfield, VA, LLB-12387, 1981. (PA)**

Techniques for measuring CO, NO_2, formaldehyde, radon, and particulates in residential indoor air space are described. A basic indoor air quality audit is proposed comprised of two steps: compiling an inventory of indoor pollutant sources (through an owner questionnaire or visual audit) and assessing the amount of pollutants injected into the home from known sources-sources with a narrow range of emission rates (e.g., gas stoves) and secondly, measuring the pollutant source strengths of unknown sources-sources with emission rates that vary widely (e.g., radon).

***Tucker, S.P., Arnold, J.E.** Evaluation of OSHA (Occupational Safety and Health Administration) Method No. 30 for Ethylene Oxide in Air with 400-mg-200-mg Charcoal Tubes. **National Institute for Occupational Safety and Health, NTIS, Springfield, VA, February 1984. PB84-242049. (NT)**

An analytical procedure based on OSHA method Number 30 for the determination of ethylene-oxide (75218) (EO) concentration was described. The method utilized sampling tubes containing 400 milligrams (mg) of charcoal in the front section and 200 mg in the back sections instead of 100 mg in the front and 50 mg in the rear as in the OSHA method. This solution converted EO to 2-bromoethanol (540512). One microliter of the sample solution was injected into a gas chromatograph equipped with an electron capture detector along with standards prepared from 2-bromoethanol. Charcoal samples that had been obtained from EO in humid air were stored at room temperature and under refrigeration for up to 28 days before being analyzed. EO migrated from the front sections of the charcoal to the back sections during storage. The authors note that EO at concentrations of 0.027 to at least 1.7 parts per million in 5 liter air samples can be determined.

Urea Formaldehyde in Building Materials. 1973-November, 1984 (Citations from the Rubber and Plastics Research Association Data Base). NTIS, Springfield, VA, November 1984. PB85-850782/XAB. (NT)

This bibliography contains citations concerning regulations and standards, safety, and applications of formaldehyde resin compositions in the building industry. Urea formaldehyde is emphasized; however, phenol formaldehyde and melamine formaldehyde are also considered for such applications as thermal insulation, bonding agents and composite construction materials. Ramifications of state and federal legislatures, substitute materials, and toxicology studies are included.

***Vu Duc, T., et al. "Characteristics of Motor Exhausts in an Underground Car Park: Mass Size Distribution and Concentration Levels of Particles." Journal of Environmental Science & Health-Environmental Science & Engineering, Vol. A16, No. 6, 1981, p. 647. 82-003393. (EN)**

A high-volume cascade impactor was used to determine the size distribution of exhaust pollutants. Sixty percent of lead and cadmium were located in particles of submicrometer aerodynamic diameter, while 80% of polycyclic aromatic hydrocarbons were absorbed on particles of less than 1.1 mm. Properties of exhaust aerosol were compared to exhaust from the environment and the emission source.

Wadden, Richard A. et al. Indoor Air Pollution: Characterization, Prediction, and Control. New York, John Wiley and Sons, 1983.

***Wesolowski, Jerome J. "An Overview of Indoor Air Quality." Journal of Environmental Health, Vol. 26, May-June 1984, p. 311. 84-005674. (EN)**

An overview of nonoccupational indoor air quality, this article addresses the sources of indoor pollutants and their health effects. A distinction is made between those pollutants generated indoors and those entering from outside. Criteria pollutants such as carbon monoxide, nitric oxide, and nitrogen dioxide tend to have higher indoor levels, while sulfur dioxide and ozone have lower values. Formaldehyde and radon concentrations typically found indoors are discussed. Monitoring and mitigation procedures are explained, and goals of the California Indoor Air Quality Program are cited.

West Virginia University. MSHA (Mine Safety and Health Administration) Approved Mine Resource-Training Module (Metal/Nonmetal): Mine Ventilation. NTIS, Springfield, VA, MSHA-2203, 1984. PB84-203058. (NT)

Mine rescue teams play a critical role in restoring mine ventilation after a disaster. Teams explore specifically to assess damages, measure airflow conditions and check damages to ventilation controls. Teams often alter ventilation according to orders from command officials. This training manual is intended to provide teams with background in the purpose, principles and methods of mine ventilation. The manual also covers the mine ventilation map, map symbols and airflow measuring devices. The manual takes into consideration the diversity of minerals and ores mined in metal/nonmetal mines, plus the wide range of mining techniques and terminology in different operations.

Wilkening, M., et al. Source Characterization and Transport Processes Affecting Levels of Radon and Its Decay Products in an Indoor Environment. Annual Report. NTIS, Springfield, VA, DOE/ER/60095-T1, January 5, 1984. DE84004237. (NT)

Research progress in the following areas is reported: (1) exhalation of radon and thoron from soil at a field station; (2) measurements of indoor radioactivity; (3) instrumentation development for measurement of radon, thoron, and their daughters; (4) radon levels in indoor and outdoor locations measured with passive track-etch detectors; (5) ion-aerosol interactions; and (6) a study of radon levels and their use for measuring air exchange in caves.

***Woods, J.E. "Sources of Indoor Air Contaminants." ASHRAE Transactions, Vol. 89, No. 1B, p. 462. 84-005664. (EN)**

Controlling the quality of indoor air by direct methods requires identification, location, and characterization of suspected pollutants. Indoor contaminants are characterized as two continua: mass stressors and energy stressors. Contaminant generations and transport rates are described in terms of four sources: outdoor air, building information concerning the effects of temperature, humidity, and other factors on pollutant generation rates is culled from the literature. Indoor emissions of tobacco smoke, carbon dioxide, radon, and formaldehyde are discussed.

***Wright, C.G., et al. "Chlordane and Heptachlor in the Ambient Air of Houses Treated for Termites." Bulletin of Environmental Contamination and Toxicology, Vol. 28, No. 5, May 1982, p. 617. (EN)**

Chlordane and heptachlor are used for preventative and remedial termite control in buildings. A study was initiated to determine ambient levels of these insecticides in houses after chlordane or chlordane plus heptachlor treatments. All air samples taken after application contained insecticide. Insecticide levels in the ambient air of the test houses varied greatly, with no discernible or predictable pattern.

***Yocum, John E. "Indoor-Outdoor Air Quality Relationships: A Critical Review." Journal of the Air Pollution Control Association, Vol. 32, No. 5, May 1982, p. 500. 82-004698. (EN)**

Research on indoor-outdoor air quality relationships since 1970 is reviewed. Research that has been conducted is often fragmented and has been duplicated. Problems have been the lack of a mandate to regulate indoor air quality as an aspect of exposure to pollutants and the lack of a Federal agency to organize efforts in the field. Criteria pollutants and factors influencing indoor air quality are discussed.

***Young, J.A., et al. Radiological Surveys of Properties Contaminated by Residual Radioactive Materials from Uranium Processing Sites. NRC Report NUREG/CR-2954, June 1983. 84-004627. (EN)**

Methods for determining the extent and nature of property contamination by residual radioactive materials from uranium processing sites are examined. The success of remedial actions in removing the residual activities is also assessed. Data from a literature review and practical experiences from the Edgemont, SD, radiation survey program are used to explore sampling program structures, instrumentation, analytical procedures, data reporting formats, and statistical analyses of data. Protocols are recommended for measuring indoor and outdoor gamma ray exposure rates, surface and subsurface radium 226 concentrations in soil, and radon daughter concentrations.

***Zaebst, D.D. In-Depth Industrial Hygiene Survey Report of Henredon Furniture Industries, Inc., Henredon Road, Morgantown, North Carolina. National Institute for Occupational Safety and Health, NTIS, Springfield, VA, July 1984. PB85-107597/XAB. (NT)**

Environmental and breathing zone samples were analyzed for 18 organic solvents individually and as mixtures at two facilities of Henredon Furniture Industries, Incorporated (SIC-2511), Morgantown, North Carolina on June 23 to 26, 1981. The concentrations of the individual solvents were below all current NIOSH or American Conference of Governmental Industrial Hygienists (ACGIH) recommendations. Additive exposures to solvent mixtures were 101, 121, and 125 percent of the threshold limit values at three booths in factory number 1, the older facility. Preemployment medical examinations were not required; only a simple medical history was obtained. No developed industrial hygiene program was in effect. Engineering controls consisted of using water wall spray booths equipped with over spray controls. Poor work practices such as leaving stripping solvent bins open and placing newly finished, wet furniture in unventilated areas in factory number 1 were observed. The author recommends that work practices be improved. He notes that although exposures to one of the solvents, 2-butoxyethanol, (111762), were well below the OSHA and ACGIH standards, it is not known whether these limits are adequate to protect against potential adverse reproductive health effects, as indicated in recent laboratory animal studies.

***Zawacki, T.S., Cole, J.T., et al. Efficiency and Emissions Improvement of Gas-Fired Space Heaters. Task 2. Unvented Space Heater Emission Reduction. NTIS, Springfield, VA, GRI-84/0021, June 1984. PB84-237734. (NT)**

The intent of this study was to investigate simple methods of reducing emissions, specifically NO_x, in a typical unvented space heater. The basic design was to be retained, and changes limited to minor modifications to achieve the desired results. In this respect, it was determined that a significant reduction in the NO_x levels was possible by relatively simple applications of appropriate burner inserts. However, GRI has been reviewing indoor air quality and has, subsequent to the completion of this work, added emphasis on the reduction of NO_2 as well as NO_x. In this light, the suitability of some of the reported techniques is questionable.

II. FACTORS CONTRIBUTING TO INDOOR AIR POLLUTION

***Andersen, I.B., et al. "Indoor Air Pollution Due to Chipboard Used As a Construction Material." Atmospheric Environment, Vol. 9, No. 12, 1975, p. 1121. (EN)**

Measurements in 25 rooms in 23 dwellings in Denmark where particle board is used in walls, floors, and ceilings indicate that the average concentration is 0.62 and the range is 0.08-2.24 mg formaldehyde per cubic meter of air. This exceeds the W. German TLV for occupational exposure. A mathematical model for the room air concentration of formaldehyde is developed for predicting concentrations in rooms containing particle board.

***Aurand, K., et al. "(Indoor air quality).; Luftqualitat in innenraumen." Symposium on Indoor Air Quality, Germany, October 1-2, 1981. (PA)**

The aim of this Symposium was to give an overview of the present knowledge about the quality and quantity of substances encountered in the indoor environment. The emissions of pollutants by man himself and by various other sources (e.g., building materials, gas appliances, paints and household products) were discussed, as were the problems of biological contaminants, of setting standards for indoor air and of the evaluation of results as they relate to human health. The present volume contains the papers presented at the Symposium as well as the discussions which took place between a number of the more than 250 participants.

***Berk, J.V., et al. Design of a Mobile Laboratory for Ventilation Studies and Indoor Air Pollution Monitoring. NTIS Report LBL-7817, April 1978. 80-001473. (EN)**

The design and fabrication of a mobile laboratory for research studies of ventilation requirements and energy utilization in residential and commercial buildings are described. The studies being performed will provide data needed for the establishment of energy-efficient ventilation standards.

***Berk, J.V., et al. "Field Monitoring of Indoor Air Quality." LBNL Energy & Env. Div. 1979 Report, LBL-11650, October, 1980, pp. 2-24. 81-004929. (EN)**

This report discusses an effort to establish criteria for setting energy efficient ventilation standards. The LBNL ventilation program is conducting a comprehensive assessment of indoor air quality in different types of buildings under various ventilation conditions. A mobile laboratory and other apparatus used for air sampling and analysis are described. The monitoring program has identified several air pollutants in residential, hospital and school buildings. These include particulates, sulfur dioxide, carbon monoxide, microorganisms, and ozone.

***Budiansky, S. "Indoor Air Pollution." Environmental Science & Technology, Vol. 14, No. 9, September 1980, pp. 1023-1027. (PA)**

Indoor concentrations of pollutants often equal or exceed outdoor concentrations, and outdoor concentrations may have little to do with the true exposures to pollution. Determining when, where, and how exposure occurs is the key to limiting exposure and to understanding the fundamental effects of pollution. Indoor pollutants of concern include NO_2 from gas cooking, respirable particles from smoking, formaldehyde from insulation, BaP from burning wood, and radioactive Rn gas from building materials. Much of the attention that indoor air quality has received has arisen from concern over the effects of energy conservation measures, e.g., weather-stripping and caulking, that reduce ventilation rates. With a reduction in ventilation comes an increase in the indoor concentration of any pollutant with an indoor source. The identification of indoor sources and high indoor levels of pollutants has cast a shadow on past epidemiology, which attempted to relate health effects with outdoor levels only. EPA may budget $3-4 million for indoor environment studies for fiscal year 1982; $2 million is being made available to EPA immediately through a 2-year agreement with NIOSH for 24-hour exposure profiles for workers in the electronics and biosynthesis industries.

***Burton, B., et al. Residential Wood and Coal Combustion. Task 3. Health Effects Literature Search. NTIS, Springfield, VA, EPA-450/5-83-005C, February 1984. PB84-191584. (NT)**

This report is a compilation of titles and abstracts which is the result of a literature search for information on adverse health effects due to air emissions (indoor or outdoor) from the residential combustion of coal and wood. Abstracts are presented alphabetically according to the first author's surname. This search included the files of the Combustion Research Branch, Industrial Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, N.C.; and Environmental Technology Division, Del Green Associates, Inc., Woodburn, Oregon, which has recently completed a residential wood combustion study for U.S. EPA Region X and the State of Oregon. In addition, an on-line computer literature search was performed, covering the following data bases: Biological Abstracts (BIOSIS, 1976+), National Technical Information Service (NTIS), and Excerpta Medica (1976+).

***Chase, Victor D. "Indoor Pollution: A Potential Problem in Energy-saving Houses." Builder, January 7, 1980, Vol. 3, No. 1, p. 92. 80-002137. (EN)**

Many researchers believe that the increasing implementation of energy conservation steps in residential homes is causing an indoor air pollution problem. Experiments in several government and private energy-efficient test houses that are determining the impact of energy conservation measures on indoor air infiltration are reported. Factors shown to reduce the rate of indoor air infiltration substantially and to cause an accumulation of indoor pollution include the use of vapor barriers, weatherstripping, and caulking devices. Mechanical ventilation could be the solution to most indoor air pollution problems.

***Cleary, Peter, et al. "An Overview of Some Indoor Air Quality Issues." Presented at ASES Improving Energy Efficiency in Buildings Conference, Santa Cruz, August 10-22, 1980, pp. 1-6. 83-002845. (EN)**

Two methods of decreasing building heat loss are to increase insulation levels and to decrease infiltration rates. Such energy conserving action reduces indoor-outdoor air exchanges, rendering the building a trap for a number of pollutants that are released into indoor air. Infiltration rates of existing and new homes are compared. Conservation measures that reduce air exchange can increase indoor pollutant levels by 33%. The effects of such air pollution on health have yet to be determined.

***Cohen, A.F., et al. Infiltration of Particulate Matter into Buildings. NTIS, Springfield, VA, NUREG/CR-1151, November 1979. 82-000732. (EN)**

The protection afforded by being indoors against inhalation of particulates of outdoor origin is studied. Average home protection factors of about 4 for large particles and 2 for submicron particles are calculated, but protection factors for larger buildings are higher. A ventilation model to estimate the effectiveness of sheltering in reducing the dose due to inhaled radionuclides is designed and evaluated. A protection factor of 1.5 using best estimate values for the model is indicated.

Cohen, B.G.F. Human Aspects in Office Automation. National Institute for Occupational Safety and Health, NTIS, Springfield, VA, April 16, 1984. PB84-240738. (NT)

Aspects of stress encountered in office environments are reviewed. The tighter building syndrome is defined. The syndrome refers to a high incidence of similar, nonspecific complaints such as upper respiratory irritation, headache, dizziness, or drowsiness among groups of workers who spend extended periods of time in buildings that use mechanical systems for ventilation. Toxic concentrations of substances such as carbon-monoxide (630080), nitrogen-dioxide (10102440), formaldehyde (50000), or butyl-methacrylate (97881) have been found in office environments due to malfunctioning or inadequate ventilation. Organizational factors affecting stress among clerical workers are discussed. The impact of organizational factors on visual strain experienced with video display terminals is considered. Clerical health and safety issues are noted and ergonomic aspects of the workplace are considered. Behavioral, organization, and management aspects of office automation are considered. Issues surrounding the design of ergonomic office equipment are described. Strategies for alleviating worksite stress are considered. Relaxation training in the management of job stress is recommended.

***Diamond, R.C., et al. Manual on Indoor Air Quality. Final Report. NTIS, Springfield, VA, EPRI-EM-3469, February 1984, 108 pp. PB84-240738. (NT)**

This reference manual was prepared to assist electric utilities in helping homeowners, builders, and new home buyers to understand a broad range of issues related to indoor air quality. The manual is directed to technically knowledgeable persons employed by utility companies -- the customer service or marketing representative, applications engineer, or technician -- who may not have specific expertise in indoor air quality issues. In addition to providing monitoring and control techniques, the manual summarizes the link between pollutant concentrations, air exchange, and energy conservation and describes the characteristics and health effects of selected pollutants. Where technical information is too lengthy or complex for inclusion in this volume, reference sources are given.

***Dravnieks, A. "Analysis of Indoor Air Acceptability Data from a Public Buildings Ventilation Study." ASHRAE Transactions, Vol. 89, No. 2A, 1983, p. 213. 84-006255. (EN)**

Data collected in an LBNL study on ventilation in four public buildings included sensory evaluations of indoor environments and physicochemical properties of indoor air. The database was analyzed to establish how the ASHRAE indoor odor acceptability criterion is defined as an acceptability by 80% of individuals entering the occupied space. The odor intensity alone only partially determined the odor acceptability percentage. A staleness-freshness rating correlated to the odor acceptability better than odor intensity alone.

***Eshelman, P.S. "Monitoring Industrial Process Exhaust for Recirculation." Presented at ASHRAE Semiannual Symposium, Houston, January 24-28, 1982, p. 1221. 83-004951. (EN)**

The possibility of recirculating industrial exhaust air to save energy is considered. Factors to be considered prior to the installation of a recirculation system are listed. OSHA and other federal safety regulations are discussed, and design criteria for such recirculation equipment are discussed.

Gammage, R.B., et al. Residential Measurements of High Volatility Organics and Their Sources. NTIS, Springfield, VA, CONF-840803-14, 1984. DE84016607/XAB. (NT)

A study is ongoing to measure the levels of volatile organic compounds (VOC) inside 40 homes in east Tennessee and identify some of their sources. This report focuses on the VOC with boiling points below 110° C. Concentrations indoors were usually at least tenfold higher than for outdoor air. The highly volatile VOC were generally dominated by the presence of gasoline fumes. Attached garages, automobiles, stored gasoline and motor oil were responsible for the ubiquitousness of these gasoline vapors in indoor air. Air drawn into air conditioning ductwork located in attached garages proved to an effective means of funneling gasoline and other engine exhaust fumes into the living zones of the house. Other types of VOC, including chlorinated VOC and their sources, are currently under study.

***Georghiou, P.E., et al. An Investigation of Formaldehyde Gas Levels in Houses in St. John's, Newfoundland. Canada Environmental Health Directorate Report 82-EHD-83, June 1982, 41 pp. 84-000170. (EN)**

Analytical methods and devices to determine formaldehyde gas emitted by urea-formaldehyde foam insulation (UFFI) in indoor environments in Canada that are equivalent in accuracy to the NIOSH method are evaluated. Results include the following: the MIRAN 1A is not sensitive enough to measure formaldehyde levels in the indoor air of non-industrial environments, but is suitable for measuring formaldehyde associated with outgassing of UFFI in wall cavities; the CEA 555 is a sensitive, direct onsite measuring device that can function as a continuous monitor, but requires a high degree of skill to calibrate and maintain; the precision of NIOSH or any method is limited to the degree of actual fluctuation in the indoor formaldehyde level that is dependent upon internal and external conditions; passive-type dosimeters that monitor levels over an extended time give a meaningful time-weighted average of ambient formaldehyde levels; and there is a group of UFFI-homes that contain unusually high formaldehyde levels.

***Getschow, George. "Indoor Air Pollution Worries Experts as Buildings Are Sealed to Save Fuel." Wall Street Journal, August 15, 1979, p. 6. (EN)**

Because of the trend toward more energy efficient homes, health experts are worried about rapid deterioration of indoor air quality in tightly sealed homes. Typical home pollutants include: radon found in some building materials; formaldehyde used in draperies, furniture, and carpets; carbon monoxide and nitrogen dioxide from gas appliances and self-cleaning ovens; and numerous chemicals from cleaning agents, solvents, and aerosol sprays. Health damage from such pollutants may be manifested as increased probability of disease transmission; chronic respiratory ailments; lung damage from acid, humid air; and possibly sudden infant death or other serious health problems in children. Officials of the Home Builders Assn. do not concur with these assessments, but suggest that if problems exist, homeowners should open the windows.

***Grimsrud, D.T., et al. Indoor Air Quality in Energy Efficient Residences. LBNL Report 14795, April 1983. 84-000026. (EN)**

Indoor air quality in energy-efficient residences has been measured to determine if patterns of high pollutant concentrations are associated with construction practices in new homes or in retrofits such as vapor barriers, double-glazed windows, weatherstripping, and insulation. Radon, formaldehyde, and combustion products are analyzed. Houses described in the study had low infiltration rates and low pollutant concentrations, though the range of concentrations was larger than the range of infiltration rates. These results are consistent with the viewpoint that pollutant sources, not pollutant removal mechanisms, such as ventilation, largely determine indoor air quality. While results do not show any relation between low ventilation rates and poor air quality, the small sample size is not statistically significant.

Hadley, J. "Energy Conservation and Indoor Air Quality." ASHRAE Journal, Vol. 23, No. 3, March 1981, p. 35, 30 pp. (EN)

Survey report energy conservation measures to reduce air leakage in homes have raised questions regarding possible adverse effects on air quality in homes with very low natural ventilation. The concepts of air infiltration, insulation, and 'tightness' are reviewed. Indoor air pollutants may include combustion products, airborne particles, radon, and formaldehyde; design options in homes now being built can insure both energy efficiency and suitable indoor air quality. Also, retrofitting existing homes for energy conservation should not create serious indoor air quality problems.

***Hawthorne, A.R. et al. "Formaldehyde Release from Simulated Wall Panels Insulated with Urea-Formaldehyde Foam Insulation." Air Pollution Control Association Journal, Vol. 32, No. 11, November 1982, p. 1126, 6 pp. 83-001434. (EN)**

An important potential source of formaldehyde in the home is urea-formaldehyde foam insulation. A study measured the long-term releases of formaldehyde through the interior wall of test panels foamed with commercial urea-formaldehyde insulation. The measurements, made 16 months after initial foaming, were conducted under both static and dynamic air conditions with air flow simulating a typical air exchange found in residences. Estimated room concentrations based on a simple model of uniform mixing within a room and measured emission rates are included.

***Hollowell, C.D., et al. "Energy-Conserving Retrofits and Indoor Air Quality in Residential Housing." University of California, Berkeley, presented at ASHRAE Semiannual Symposium, Houston, January 24-28, 1982, p. 875. 83-004948. (EN)**

The impact of energy-conserving retrofits on air leakage and indoor air quality is assessed for several houses in the Pacific Northwest and one home in New Jersey. The houses examined and the nature of the retrofits done to them are described, and the procedures used to test air quality and leakage areas within those houses are detailed. Conclusions indicate that the weatherization program done by the local utility in the Pacific Northwest had a minimal impact on indoor air quality. Air leakage was reduced successfully in all the houses examined.

***Hollowell, C.D. et al. Indoor Air Quality Measurements in Energy Efficient Buildings. NTIS Report LBL-7831, April 1978. 80-003527. (EN)**

The energy efficient buildings program of the U.S. Lawrence Livermore Lab., Calif., has designed and fabricated a mobile laboratory for R&D studies of ventilation and energy utilization in residential and commercial buildings. Indoor air quality in buildings has been measured before and after energy conservation retrofits. Work in progress includes indoor air quality monitoring in schools, hospitals, and energy-efficient buildings. The monitoring program measures indoor air levels of carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen oxide, nitrogen dioxide, and ozone, and the infiltration rates of these substances on a continuous basis. Preliminary results of the program indicate particulate air pollutants in specific indoor environments exceed the levels commonly found in the outdoor urban air environment.

***Iker, Sam. "Clearing the Air on Indoor Pollution." National Wildlife, Vol. 19, No. 5, August-September 1981, p. 16. 81-006229. (EN)**

Although indoor air pollution is an old problem, it has been accentuated recently by energy conservation. Highly insulated homes tend to trap air and allow pollutants to build to hazardous levels. Formaldehyde, carbon monoxide, radon gas, and oxides of nitrogen are a few common pollutants. Factors causing indoor pollution are examined, and preventive measures are recommended.

Jones, T. Indoor Air Pollution. NTIS, Springfield, VA, PB80-851280, 1980. (PA)

This bibliography covers world-wide literature on indoor air pollution. The sources for such pollution can arise from inside the building, from outdoor aerosols and gaseous pollutants entering the building through infiltration and, in a few cases represented by the abstracts, from the building construction materials. The effect of various ventilation techniques on the indoor air quality is explored and reported on.

***Jones, W.R., Stricker, S. "Ventilation Requirements and Natural Air Leakage in Residences." Ontario Hydro Research Review, No. 4, December 1981, p. 17. 82-005402. (EN)**

The problem of achieving sufficient air ventilation through natural leakage in energy-efficient homes is discussed. Contamination levels of carbon dioxide, water vapor, odors, carbon monoxide, formaldehyde, ozone, nitrogen dioxide, and radon may occur. Further studies are needed in such areas as removal of contaminants, ventilation control by contaminant level, and control of house tightness.

***Langenborg, R. "Ventilation-Indoor Air Quality Data Base." LBNL Energy & Environment Division, 1979 Report LBL-11650, October 1980, pp. 2-39. 81-004930. (EN)**

The ventilation-indoor air quality data base is a computerized information service developed by the LBNL ventilation program. The data base consolidates existing information with current research developments of air quality in energy efficient structures. Typical interest areas included in the system are: airborne microbes, building envelope, energy conservation, epidemiology, field studies, formaldehyde, heat exchangers, infiltration, radon, odors, organic compounds, and mathematic models.

***Leaderer, B.P. "Air Pollutant Emissions from Kerosene Space Heaters." Science, Vol. 218, No. 4577, December 10, 1982, p. 1113. 83-002833. (EN)**

Air pollutant emissions from portable convective and radiant kerosene space heaters were measured. Emission factors for nitrogen oxides, sulfur dioxide, carbon monoxide, carbon dioxide, and oxygen depletion are examined. The use of such heaters in residences can result in exposures to pollutants in excess of ambient air quality standards.

***Lints, M.C., et al. "A Study of Air Infiltration in Tight Homes." Presented at ISES-AS/ET AL Passive Solar 6th National Conference, Oregon, September 8-12, 1981, Vol. 6, p. 441. 82-000064. (EN)**

Studies were conducted to measure infiltration and indoor air quality in a number of homes in Rochester, N.Y. Leakage areas in energy conserving residences were identified. The thermal performance and indoor air quality impact of mechanical ventilation systems employing air-to-air heat exchangers were evaluated. Average weekly infiltration rates as low as 0.2 air changes per hour were measured. Measured levels of radon, nitrogen dioxide, and formaldehyde were low.

***Maldonado, E.A., et al. "Ventilation Efficiency as a Means of Characterizing Air Distribution in a Building for Indoor Air Quality Evaluation." ASHRAE Transactions, Vol. 89, No. 2B, 1983, p. 496. 84-006256. (EN)**

The characterization of the air exchange between a building and the environment is important for the estimation of its energy consumption and indoor air quality. A multi-point tracer gas technique used to quantify the air-exchnage rate in different zones of various residential buildings is explained. Zonal ventilation rates are expressed mathematically according to an empirical index. Test results demonstrating the efficacy and benefits of the technique are reported.

***Mejzner, T.A. "Energy Conservation and Its Impact on Indoor Air Pollution." Air Pollution Control Association 6th Annual Symposium, New Brunswick, Canada, September 29-30, 1982, p. 46. 84-001430. (EN)**

Insulation, weatherstripping, and other residential energy conservation measures reduce ventilation rates needed to maintain adequate interior air quality levels. Reduced infiltration can result in a buildup of pollutants released inside homes. Various types of indoor pollutants, including radioactive contaminants, carbon monoxide, and emissions from formaldehyde, are identified. Energy conservation can be achieved without reducing ventilation or air exchange rates by use of heat pumps, heat exchangers, and proper house design.

***Moschandreas, D.J., et al. "Effects of Woodburning on the Indoor Residential Air Quality." Environment International, Vol. 4, Nos. 5 & 6, 1980, pp. 463-468. (PA)**

Data from suburban residences in the Boston metropolitan area reveal a potential adverse impact on indoor air quality from woodburning in woodstoves and fireplaces. Ambient pollutant concentrations at each residence were compared to corresponding pollutant levels indoors at three locations (kitchen, bedroom, and activity room). Individual gaseous pollutant samples were averaged on an hourly basis while 24-hour integrated samples of particulate matter were obtained. Ten gaseous pollutants were sampled along with total suspended particulates (TSP). Chemical analyses further determined ten components of TSP, including trace metals, benzo-a-pyrene (Ba-P), respirable suspended particulates (RSP), and water soluble sulfates and nitrates. Monitoring lasted two weeks at each residence and was conducted under occupied real-life conditions.

Moschandreas, D.J., Morse, S.S. "The Effects of Residential Energy Conservation on the Indoor Air Quality." Presented at Information Transfer Inc/et al Technology for Energy Conservation Conference, January 23-25, 1979, p. 613. (EN)

Energy conservation measures implemented to reduce air exchange rates in residences are expected to affect indoor air quality both adversely and beneficially. The use of gas and electric appliances in homes with low air exchange rates accentuates adverse impacts because the contaminated air cannot exfiltrate. The indoor environment provides a shelter from ambient exposures to such chemically reactive pollutants as NO_2. Inhabitants of houses with indoor pollutant sources experience higher 24 hr exposures indoors than outdoors.

Moschandreas, D.J., et al. "The residential environment & energy conservation: Predicting indoor air quality." 71st Air Pollution Control Association Annual Meeting and Exhibition, June 25-30, 1978. (PA)

The GEOMET Indoor-Outdoor Air Pollution (GIOAP) model predicts indoor pollutant concentrations as a function of outdoor levels, indoor pollutant sources and sinks, and the air exchange rate. The GIOAP model, based on a mass balance principle, has been validated on the data base generated by the field experiments of an 18-month monitoring program of residences. It predicts indoor pollution concentrations within 20% of the observed hourly indoor values for carbon monoxide (CO), nitrogen oxide (NO), nitrogen dioxide (NO_2), carbon dioxide, and total hydrocarbons-methane. A series of numerical simulations using the GIOAP model show that under certain conditions involving gas appliances, indoor CO, NO and NO_2 concentrations increase substantially. Under these same conditions carbon monoxide concentrations reach levels that violate the hourly ambient national standard. This is of particular current concern because this violation may be attributed to energy conservation measures and the resulting decrease in the air exchange rates. The dynamics of energy conservation and indoor residential air quality are investigated and a series of optimization procedures are discussed by predicting the indoor pollutant concentrations as a function of varying air exchange rates, indoor emission rates, and filtering devices.

Narasaki, M., et al. "Indoor Air Pollution and Ventilation in Sound Insulating Dining-Kitchens." Technical Reports, Osaka University, Vol. 31, No. 1600, 1981, pp. 145-152. (PA)

This paper presents as its primary focus new data acquired by experiments on the ventilation rates and the indoor air pollution caused by combustion, in the dining-kitchen (D.K.) of sound insulating houses. CO and CO_2 were employed as tracer gases. From the decay of these concentrations, the ventilation rates were estimated, and from the elevation of CO and CO_2 levels, the indoor air pollution was estimated. Moreover, the effect of a supply fan or exhaust fan on the control of ventilation and on the leak rates for exhaust by combustion was investigated from the level of air pollution and rates of ventilation. This paper points out unsolved problems such as (1) indoor air pollution in D.K. caused by the air-tightness of buildings, and (2) ventilation systems for air cleaning.

***National Research Council. Abestiform Fibers: Nonoccupational Health Risks. Washington, D.C., National Academy Press, 1984.**

National Research Council. Formaldehyde and other Aldehydes. Washington, D.C., National Academy Press, 1984.

***National Research Council. Indoor Pollutants. Washington, D.C., National Academy Press, 1981.**

Nero, A.V., et al. Air Quality Issues in Ventilation Standards. NTIS, Springfield, VA, LBL-18139; CONF-841049-1, Jul. 1984. DE84016899/XAB. (NT)

An ASHRAE Standard 62-1981 contains two distinct procedures that can be used to set ventilation rates. The first is a prescriptive specification that mandates ventilation rates for particular building types. The second is a performance specification that uses target concentrations of indoor contaminants as the basis for deciding the adequacy of ventilation rates. This paper comments on the latter procedure. Several issues are discussed: (1) the lack of a consistent criterion for choosing concentration limits for indoor pollutants, (2) the potential for adverse air quality if the performance specification is adopted in a building, and (3) the practical difficulties in implementing the second option. Several suggestions for improving the Standard are made.

***Nero, A.V., et al. "Radon Concentrations and Infiltration Rates Measured in Conventional and Energy-Efficient Houses." Health Physics, Vol. 45, No. 2, 1983, p. 401-505. (CA)**

To elucidate any connection between high Rn concentrations and low-infiltration houses, the 222Rn concentration and the infiltration rate were measured in U.S. houses. Three housing surveys were undertaken: one in energy-efficient houses located throughout the U.S. and 2 in conventional houses in the San Francisco area and in Maryland. In each of the groups surveyed, no clear correlation was observed between 222Rn concentrations and infiltration rate, although each parameter varied over a wide range. Infiltration rates for the entire sample, numbering 98 houses, ranged between 0.02 and 1.6 air changes/h, and 222Rn concentrations ranged from 0.1 to 27 PCI/L. It appears that the major cause of the observed differences in 222Rn concentrations is variation from one house to another in the rate at which 222Rn enters houses from its sources.

***Offermann, F.J., et al. Midway House-Tightening Project: A Study of Indoor Air Quality. LBNL Report 12777, May 1981. 82-005441. (EN)**

Concern has arisen that domestic energy conservation measures reduce the natural ventilation of houses and thus degrade indoor air quality. A study of indoor air quality in 12 retrofitted houses was conducted. Measurement of effective leakage areas and average concentrations of nitrogendioxide, formaldehyde, and radon were made before and after special house-tightening modifications. None of the pollutants measured before or after retrofits reached levels exceeding existing guidelines.

Peach, Jack. "Environmental Comfort and Energy Conservation." Royal Society of Health Journal, Aug. 1982, Vol. 102, No. 4, p. 162. (EN)

The effects of building energy use and other factors on human comfort are investigated. The amount of energy required to produce comfortable levels of humidity, air movement, sound, and lighting are discussed. Ways in which a building can be optimized for human comfort with a minimal amount of energy expenditure depends on the form of energy chosen, the advantageous use of all natural resources and phenomena, and the recovery of as much wasted energy as possible.

Perkins, W.C., et al. Dispersion Model for Airborne Particulates Inside a Building. NTIS, Springfield, VA, DP-MS-83-136; CONF-840806-2, Jul 84, DE84014961. (NT)

An empirical model has been developed for the spread of airborne radioactive particles after they are released inside a building. The model has been useful in performing safety analyses of actinide materials facilities at the Savannah River Plant (SRP), operated for the US Department of Energy by the DuPont Company. These facilities employ the multiple-air-zone concept; that is, ventilation air flows from rooms or areas of least radioactive material hazard, through zones of increasing hazard, to a treatment system. A composite of the data for dispersion of airborne activity during 12 actual case incidents at SRP forms the basis for this model. These incidents occured during approximately 90 plant-years of experiments at SRP with the chemical and metallurgical processing of purified neptunium and plutonium after their recovery from irradiated uranium. The model gives ratios of the airborne activity concentrations in rooms and corridors near the site of the release. All data are normalized to the data from the air sampler nearest the release point. The model can be applied in predicting airborne activity concentrations from particulate releases elsewhere, if the facility in question is similar in floor plan, air velocity, and air flow direction. The multiple-air-zone concept has been applied to many designs of nuclear facilities as a safety feature to limit the spread of airborne activity from a release. The model illustrates the limitations of this concept: it predicts an apparently anomalous behavior of airborne particulates; namely, a small migration against the flow of the ventilation air. The following phenomena are suggested as possible mechanisms for this migration: eddy currents in the air flow; leaks of ventilation air between zones; open doors; movement of personnel during an incident; inadequate flow of ventilation air; and thermal gradients.

Puntilla, A., et al. Indoor Air Quality and Energy Conservation. Proceedings of the W67 Workshop Held at Helsinki on 15 June 1983. NTIS, Springfield, VA, CIB/PUB-77; CIB/W-67, 1984. PB85-119782/XAB. (NT)

These Proceedings consist of papers presented at the CIB W67 Meeting on Indoor Air Quality and Energy Conservation, held at the Laboratory of Heating, Ventilation and Air Conditioning in Helsinki University of Technology, Otaniemi, Finland, 15th June 1983, with Professor Oil Seppanen as the Chairman of the Workshop.

Residential Wood and Coal Combustion. **Air Pollution Control Association Wood and Coal Combustion Symposium Proceedings, Louisville, KY, March 1-2, 1982. p. 308. (EN)**

Conference proceedings on methods of wood and coal combustion in households and emission monitoring are presented. Topics discussed include: improved combustion in wood stoves; emission and thermal performaor an unbaffled, airtight wood appliance and a box-type catalytic appliance; effects of firing rate and design on domestic wood stove performance; solid fuel-fired heating; residential stove emissions from coal and other alternative fuel combustion; measurement techniques and emission factors for hand-fired stoves; an outdoor exposure chamber to study wood combustion emissions under natural conditions; impact of residential wood combustion appliances on indoor air quality; and indoor exposure to carbon-containing particulates and vapors in homes that burn wood for heating.

***Ritchie, Ingrid M., et al. "Residential Air Pollution From Kerosene Heaters." Journal of the Air Pollution Control Association Vol. 33, No. 9, 1983, p. 879-881. (CA)**

An outside air exchange area of greater than or equal to 4 in .2/1000 BTU H of kerosene heater capacity, a recommendation of some manufacturers, should be provided to minimize the accumulation of contaminants. Purchasing an oversized heater or operating a heater in a smaller room than that for which it was intended will result in high, and possibly unsafe concentrations of air pollutants. Simply opening a door to another room is not an effective way of providing ventilation because pollutants will still continue to build up, but at a slower rate.

***Roper, W., et al. "Wood Stoves: Can We Solve the Emissions Problem Before it Goes up in Smoke?" Boston College Environmental Affairs Law Review, 1984, Vol. 11, No. 2, p. 273. *84-004232. (EN)**

The Northeastern and Southeastern U.S. rely heavily on wood fuel for residential heating purposes, and concern is growing over health hazards from wood stove emissions. Some of the more critical pollutants include particulates, hydrocarbons, carbon monoxide, and polycyclic organic material. Private control includes retrofitting stoves for more efficient combustion, manufacturer improvements, and fire insurance rates to promote efficiency. Public control includes federal and state programs, including the Clean Air Act, NEPA, the Internal Revenue code, and state implementation plans.

***Sandberg, Mats, et al. "The Use of Moments for Assessing Air Quality in Ventilated Rooms." Building & Environment, Vol. 18, No. 4, 1983, p. 181. 84-005606. (EN)**

The method and theory underlying adaptation of the residence time or age concept to problems occurring within ventilation engineering are discussed. The technique is based on evaluating the moments of concentration vs. time curves of contaminants or tracer gas. The concept is applicable to characterize either the diffusion of supplied air or contaminants released in rooms. Mathematical models depicting the diffusion and flow of airborne contaminants in a ventilated room are described. Results from 50 tests demonstrate the validity of this air quality assessment approach.

***Schutte, W.C., et al. "Formaldehyde Levels in Homes Insulated with Urea-Formaldehyde Foam." Environmental Monitoring & Assessment, Vol. 1, No. 3, 1982, p. 257. 82-005530. (EN)**

A study of 27 homes in Colorado and Wisconsin that were insulated with urea-formaldehyde foam is discussed. Formaldehyde levels in these homes averaged 0.059 ppm. The impact of ambient climatic conditions was studied by the close monitoring of two homes in particular.

Silberstein, S. "Energy Conservation & Indoor Air Pollution." Energy & Buildings, Vol. 2, No. 3, Aug. 79, p. 185. (EN)

A mathematical model to predict the effects of tighter building envelopes on indoor pollutant levels is described. The model takes into account indoor and outdoor air pollutant concentrations, pollutant production rate per building unit volume, and the rates of ventilation and infiltration. Model results indicate that if conservation measures are carried out in a balanced manner (i.e., envelopes are tightened at the same time that sufficient insulation is added), there should be no increase in indoor air pollution.

***Silberstein, S. "Outdoor Sources of Indoor Air Pollution." Energy & Buildings, Vol. 2, No. 1, Jan. 1979, p. 55. (EN)**

A model relating the outdoor concentration to the indoor concentration of any air pollutant is developed. The model predicted that both outdoor and indoor pollution levels would follow a daily cycle. For pollution generated solely outdoors, maximum outdoor pollutant levels were reached before the indoor air pollutant levels reached their maximum. The maximum indoor pollution levels were also lower than the maximum outdoor pollution levels because of the effects of building construction. Lowering the air exchange rate would probably increase indoor pollutant levels. The extent of protection offered against outdoor-produced air pollution by tightening building envelopes is also estimated.

***Smay, V.E., et al. "Heat-Saving Vents: Are They the Solution to Indoor Pollution?" Popular Science, Vol. 222, No. 1, Jan. 1983, p. 78. 83-004913. (EN)**

Well-insulated homes contribute significantly to residential sector energy conservation, but also contain air that may be two to three times more polluted than outside air. Reduced infiltration in energy efficient homes trap air pollutants that are generated indoors. The main culprits of these pollutants are formaldehyde, radon, particulates, and carbon monoxide from insulation and appliances. The use of air-to-air heat exchanger systems to reduce indoor pollution while maintaining conservation levels is surveyed.

***Spengler, J., et al. "Indoor Air Pollution, Proceedings of the International Symposium on Indoor Air Pollution, Health, and Energy Conservation." Environment International, Vol. 8, No. 1-6, 1982.**

Steel, F. "Airtight Houses and Carbon Monoxide Poisoning." Canada Building Digest, Mar. 1982, p. 222. (EN)

Gas authorities in Canada have noticed an increase in complaints of gas odors in private homes. Carbon monoxide poisoning has also been on an upswing. This situation is associated with fireplaces and poor air infiltration into homes. Many records on the problem do not establish a correlation between CO and venting failures in the chimney. Some of these accidents may have been caused by chimney blockage. A study of the relationship between CO poisoning and the airtightness of a house was undertaken.

***Sterling, T.D., et al. "Indoor Byproduct Levels of Tobacco Smoke: A Critical Review of the Literature." Journal of the Air Pollution Control Association, Vol. 32, No. 3, 1982, p. 250-259.**

***Sterling, T.D., et al. "Use of Gas Ranges for Cooking and Heating in Urban Dwellings." Air Pollution Control Association Journal, Vol. 31, No. 2, Feb. 1981, p. 162. 81-002830. (EN)**

While several investigations have isolated kitchen gas ranges as a major source of indoor air pollution, such studies have only considered the normal operation of gas ranges for cooking. Two studies to assess the extent to which gas ranges are being used to heat urban dwellings are discussed. On the basis of gas consumption data and temperature measurements obtained in New York City during 1977, and actual observations of supplemental heating practices with gas ranges in 120 homes in the South Bronx, New York City, it is estimated that some 50-55% of New York City's gas ranges are used for both cooking and heating. Increased human exposure to carbon monoxide and nitrogen dioxide as a result of these practices is discussed.

***Stowlwijk, J. "Health Effects of Indoor Air Contaminants." ASHRAE Transactions, Vol. 89, No. 1B, 1983, p. 498. 84-005665 (EN)**

Concern over air quality in nonoccupational environments is growing in light of reduced ventilation and increased acceptance of energy conservation measures, which serve to trap pollutants indoors. A review of current knowledge on the health effects of indoor air contaminants focuses on tobacco smoke, carbon monoxide, nitrogen dioxide, formaldehyde, radon, asbestos, and biological agents. Further research in this field is warranted to formally establish theshold levels and standards for health protection.

Traynor, G.W., et al. Indoor Air Pollution and Inter-Room Pollutant Transport Due to Unvented Kerosene-Fired Space Heaters. NTIS, Springfield, VA, LBL-17600; CONF-840803-2, Feb. 1984. DE84015949/XAB. (NT)

Two kerosene-fired space heaters, one white-flame convective and one blue-flame radiant, were operated in the master bedroom of an unoccupied house under several simulated use conditions. Tests were conducted with the bedroom door and outside window closed, with the door closed and the window open 2.5 cm, with the door open 2.5 cm and the window closed, and with the door wide open and the window closed. The heaters were operated until an 8° C temperature rise was achieved in the room. Increases in bedroom concentrations of CO, CO_2, NO, NO_2, and O_2 are reported. The increases in CO_2 levels ranged from 2440 to 5440 ppM while the increases in NO_2 levels ranged from 0.12 to 0.60 ppm. In addition, inter-room pollutant transport rates are reported for tests conducted with the window closed. While inter-room pollutant transport rates were less than 10 m^3/h with the bedroom door closed, they were 30 ± 10 m^3/h with the bedroom door open 2.5 cm, and ranged from 190 m^3/h to 3400 m^3/h with the door fully open (74 cm).

Traynor, Gregory W., et al. "Indoor Air Pollution from Portable Kerosene-Fired Space Heaters, Wood-Burning Stoves, and Wood-Burning Furnaces." Residential Wood and Coal Combustion, Special Conference Proceedings, 1982, p. 253-263. (CA)

CO_2, CO, NO, NO_2 AND HCHO (50-00-0) were emitted by both radiant and convective kerosene heaters, and radiant heaters also released trace amounts of fine particles in lab tests. Emissions per fuel calorie consumed increased with decreasing wick length for CO and HCHO. In a 27-M3 environmental chamber, with only 0.4 air changes/H, 1-H operation of the heaters produced CO_2 concentrations well above the U.S. workplace standard and NO_2, well above the California short-term outdoor standard. Levels of CO, NO, NO_2 and SO_2 in occupied homes heated by wood-burning stoves and furnaces increased during stove operation, but pollutant levels were generally below the standard limits.

***Traynor, G.W., et al. "Technique for Determining Pollutant Emissions From a Gas-Fired Range." Atmospheric Environment, Vol. 16, No. 12, 1982, pp. 2079-2987. (PA)**

Laboratory measurements of pollutant emissions from a gas-fired range have shown that carbon monoxide, nitric oxide, nitrogen dioxide, sulfur dioxide, formaldehyde and respirable particles were all emitted during the combustion process. Carbon was found to be the dominant element of the respirable particles emitted. A mathematical indoor air quality model was applied to laboratory studies to calculate pollutant emission rates per caloric value of fuel consumed. The model was also used to calculate the temporal profile of the indoor pollution concentrations as well as to determine indoor pollutant decay rates from mechanisms other than air infiltration. Comparisons of measured and calculated data showed good agreement, and suggest that this model may be useful for determining pollutant emissions from a wide variety of other sources, for estimating pollution levels in other indoor environments, and for evaluating pollutant control strategies.

***Turiel, I., et al. "Effects of Reduced Ventilation On Indoor Air Quality in an Office Building." Atmospheric Environment, Vol. 17, No. 1, 1983, pp. 51-64. (PA)**

Indoor air quality was monitored at an office building in San Francisco, CA where occupants had registered eye, nose and throat irritation complaints. Portable air pollution monitoring equipment was placed on site to monitor air outdoors and at three indoor sites (a waiting room, an interview room and an office room), and data were taken under two different ventilation rates. The parameters measured were outside air flow rates, temperature, relative humidity, odor perception, microbial burden, particulate mass, formaldehyde and other organics, carbon dioxide, carbon monoxide and nitrogen dioxide. Carbon dioxide concentrations increased as the ventilation rate decreased; odor perceptibility increased slightly at the lowest ventilation rate, and other pollutants generally showed very low concentrations, which increased when ventilation was reduced.

Turiel, I., _et al_. "Energy Savings and Cost-Effectiveness of Heat Exchanger Use as an Indoor Air Quality Measure in the BPA Weatherization Program." _Energy_, Vol. 8, No. 5, 1983, pp. 323-335. (PA)

The authors examine the energy impact and cost effectiveness of heat exchanger utilization in tightened homes in the BPA region. Significant energy savings are predicted if homes are tightened and heat exchangers are utilized. From the homeowner's perspective, the results of our economic analysis indicate that, at the relatively low residential electric rates in the BPA region, the use of heat exchangers in existing homes that are tightened is not economically viable. On the other hand, from the utility perspective, it may be cost effective to use heat exchangers in the weatherization program if the marginal cost to the utility is compared with the cost of conserved energy.

***Wade, W.A., _et al_. "A Study of Indoor Air Quality." _Air Pollution Control Association Journal_, Vol. 25, No. 9, Sep. 1975, p. 933. 76-000049. (EN)**

An indoor-outdoor sampling program is described for nitric oxide, nitrogen dioxide, and carbon monoxide in four private houses with gas stoves. The houses represent different surrounding land use, lifestyles, and house age and layout. Indoor levels of NO and NO_2 are direct and CO in the kitchen exceeds air quality standards, if such outdoor standards were applied to indoors. Oxidation of NO to NO_2 does not appear to occur indoors to a significant degree.

***Weschler, C.J., _et al_. "The Effect of Building Fan Operation on Indoor-Outdoor Dust Relationships." _Air Pollution Control Association Journal_, Vol. 33, No. 6, Jun. 1983, p. 624. 83-006113. (EN)**

Fans in many Bell Telephone facilities operate only when necessary rather than continuously as part of an energy conservation effort. The effects of fan operation on indoor-outdoor dust relationships were monitored at two telephone offices. Fine and coarse aerosol particles were collected at office sites in Wichita, KS, and Lubbock, TX. Indoor dust concentrations typically increased when the fans were off. This increase was due to a loss of constant filtration. An expression is derived for the relative dust increase when the building fans are switched off.

Wilson, D.J., et al. **"Critical Wind Speeds for Maximum Exhaust Gas Reentry from Flush Vents at Roof Level Intakes."** **ASHRAE Semiannual Sym.**, Houston, Jan. 24-28, 1982, p. 503. **83-004946. (EN)**

A method of predicting the critical wind speed which would produce unacceptable amounts of contaminated air entering intake vents in considered. Existing prediction methods for minimum dilution, taken from ASHRAE Handbook, 1981, are examined. The analysis undertaken is restricted to flush vents on flat roofed buildings. The results of the analysis indicate that the ASHRAE Handbook predictions give reasonably conservative estimates for buoyant plumes, but may overestimate inlet contamination at flush roof intakes by vertical momentum jets from uncapped flush vents.

Woods, J.E., et al. **"Ventilation, Health & Energy Consumption: A Status Report."** **ASHRAE Journal, Vol. 21, No. 7, Jul. 1979, p. 23. (EN)**

Changes to codes and standards that could jeopardize the health, safety, or welfare of building occupants are being proposed in the name of energy conservation. Many factors can influence indoor air quality. If sufficient ventilation rates to meet foreseeable variations are not prescribed, the resultant low level of indoor air quality could be deleterious to health. But if sufficient ventilation rates are prescribed to meet all contingencies, the energy requirements for thermal control wil be excessive. An ASHRAE Standards Committee is revising codes for natural and mechanical ventilation. Concerns about indoor air quality are discussed.

Woods, J.E., et al. **"How Ventilation Influences Energy Consumption and Indoor Air Quality."** **ASHRAE Journal, Vol. 23, No. 9, Sep. 1981, p. 40. (EN)**

Control strategies for combining healthy indoor air quality with energy efficiency are outlined. The conventional interpretation of minimum ventilation rates as a maximum for design purposes is analyzed. New control strategies--steady-state circulation and variable generation rates--have been added to the common methods of source control, dilution control, and removal control.

III. HEALTH EFFECTS OF INDOOR AIR POLLUTION

***Albright, B.E., et al. Health Effects of Occupational Exposure to Carbon Disulfide. NTIS, Springfield, VA, May 1984. PB85-110229/XAB. (NT)**

A survey of workers exposed to carbon-disulfide (75150) (CS_2) at concentrations below the current standard of 20 parts per million (ppm) was conducted. The cohort consistent of 146 male workers at a rayon staple factory (SIC-2823). The comparison group consisted of 233 workers at the same facility having no CS2 exposure. The average ages of the cohort and comparisons were 38.2 and 33.9 years, respectively. Subjects were administered comprehensive medical examinations that included neurological, endocrine, metabolic, reproductive, and cardiovascular evaluations. Industrial hygiene sampling for CS_2 was performed. CS_2 concentrations ranged from 0.58 to 12.64 ppm. Exposed workers showed very little increased morbidity, but data indicate exposure dependent increases in pathological changes such as increased frequency of angina and myocardial infarction, systolic and diastolic blood velocity, increased symptoms of muscular weakness, increased low density of lipoproteins, increased fasting blood sugar, increased proportion of abnormal sperm forms, and increased incidence of retinal abnormalities. The authors conclude that the present standard of 20 ppm leaves little margin of safety. Additional research on the cardiovascular toxicity of CS_2 and review of the current standard are recommended.

***Allen, R.J., et al. "Analysis of Indoor Concentrations of Carbon Monoxide and Ozone in an Urban Hospital." Environmental Research, Vol. 27, No. 1, Feb 82, p. 136. (EN)**

Carbon monoxide and ozone levels were monitored in an office and two urban hospital intensive care units for one year. Annual average indoor CO concentrations averaged 0.2-1.3 ppm higher than outdoor concentrations, stemming from indoor CO sources such as smoking. Observed CO levels were well below national health standards; however, these inside emissions should be minimized because of the unknown long-term effect on high-risk groups. Indoor O_3 concentrations were less than outdoor levels.

Apol, A.G., et al. Health Hazard Evaluation Report HETA 83-014-1343, North Clackamas School District No. 12, Milwaukie, Oregon. NTIS, Springfield, VA, HETA-83-014-1343, Jul. 1984. PB85-102903/XAB. (NT)

To determine if symptoms of headache, fatigue and mood changes experienced by the three workers in the phototypesetting room were a result of occupational exposures, environmental air samples were collected to determine exposures to the phototypesetting chemicals. In addition, temperature, relative humidity, and carbon dioxide concentrations were monitored. NIOSH investigators determined that the adverse health effects experienced by the workers in the phototypesetting room could be a result of a lack of any air being supplied to the room resulting in a increase in temperature and carbon dioxide levels; low concentrations of acetic acid vapors; glare on the VDT screen; and nonadjustable viewing of the screen.

Arndt, R., et al. Potential Office Hazards and Controls. NTIS, Springfield, VA, Sep. 1984. PB85-139210/XAB. (NT)

The paper was written for OTA to assist in preparation of the report Preventing Illness and Injury in the Workplace. It discusses office worker exposure to indoor air pollution in tightly insulated buildings; potentially harmful psychological stress from poorly designed jobs and potentially harmful physical stress from poorly designed machines and work stations. Various controls for these hazards are considered and evaluated.

***Baggs, S.A. "The Lithotecture of Australia: With Specific Reference to User Health Factors." Earth Sheltered Building Design Innovations Conference, Apr. 18-19, 1980, p. II-19. 82-000761. (EN)**

Studies were conducted to investigate the quality of indoor air in Australia's underground dwellings. The existence of a considerable differential between the ratios of positive to negative small gaseous air ions present in the lithospace was documented and compared with ambient air. This type of an atmosphere is considered to be beneficial to the health of the occupant.

***Breysse, P.A. "Health Hazard Implications of Proposed and Adopted Indoor Air Standards for Formaldehyde." IES Environmental Technology 29th Technical Symposium, Los Angeles, April 19-21, 1983, p. 293. 84-002860. (EN)**

Minnesota, Wisconsin, and ASHRAE have adopted indoor air level criteria for formaldehyde. Health hazards associated with exposure to formaldehyde in homes, including cancer, are surveyed. Urea-formaldehyde-bonded particle board and urea-formaldehyde foam insulation are the two most important sources of this indoor air pollutant. The need for further research concerning this issue is discussed.

***Brown, R.D.** **Health and Environmental Effects of Oil and Gas Technologies: Research Needs. July 1981. 82-002899. (EN)**

Health and environmental issues associated with oil and gas technologies -- both those existing and those expected to emerge over the next two decades -- are discussed. Areas of concern are: offshore accidents, refineries, worker health, oil spills, soil contamination, effects of drilling fluids, indoor air pollution, unconventional resources, and technology transfer, in addition to exhaustive research on hydrocarbon contamination of the air and water. A literature survey of pertinent oil and gas data is provided.

Shirley Institute. "Cotton Dust and Byssinosis." Cotton Dust Hazards Conference, Manchester, England, February 9-10, 1983. (EN)

Exposure to cotton, flax, or soft dust over a period of years may result in the respiratory disease known as byssinosis. The connection between exposure to cotton dust and the effects on the cotton workers' health is examined. The method most commonly used for dust control is extraction within an airstream: suction is provided by fans and the impurities are conveyed through a ducted system to a central filter plant. Topics discussed include diagnosis and epidemiology of byssinosis, dust control enforcement, and practical problems associated with dust control.

***Dally, K.A., et al. "Formaldehyde Exposure in Nonoccupational Environments." Archives of Environmental Health, Vol. 36, No. 6, November-December 1981, p. 277. 82-003380. (EN)**

Wood products and foam insulation may release free formaldehyde where urea-formaldehyde resins have been used. The Wisconsin Division of Health has investigated 100 structures, collecting air samples in midget impingers and analyzing them for formaldehyde content. Concentrations ranged from below the level of detection to 3.68 ppm, with burning eyes, runny nose, eye irritation, headache, and cough the primary symptoms. Data suggest that nonoccupational indoor formaldehyde exposure is significant.

***Dodge, R. "The Effects of Indoor Pollution on Arizona Children." Archives of Environmental Health, Vol. 37, No. 3, May-June 1982, p. 151. 82-006106. (EN)**

The respiratory health of a large group of Arizona school children exposed to indoor air pollutants is reported. A significant relationship was found between parental smoking and symptoms of cough, wheeze, and sputum production. Also, children in homes where gas cooking fuel was used had higher rates of cough than children in homes where electricity was used. No differences in pulmonary function or yearly lung growth rates occurred among subjects grouped by exposure to tobacco smoke or cooking fuel.

***Dworkin, T.M., et al. "Liability for Formaldehyde-Contaminated Housing Materials: Toxic Torts in the Home." American Business Law Journal, Vol. 21, No. 3, Fall 1983, p. 307. 84-006251. (EN)**

Lawsuits arising from injuries caused by formaldehyde are increasing, threatening the viability of some businesses and straining the legal system. Because formaldehyde is present in a wide variety of products in daily use, the potential for litigation is overwhelming. Several causes of action that may provide recovery for consumers injured by toxic housing materials are discussed: negligence, implied warranty of habitability, implied warranty of merchantability, and strict liability in tort. The applicability of each of these is examined, and legislative proposals providing for compensation are assessed.

***Environmental Protection Agency. "Carcinogen Assessment of Coke Oven Emissions." NTIS, Springfield, VA, EPA-600/6-82-003F, February 1984. PB84-170182. (NT)**

Coke oven workers in Allegheny County, Pennsylvania and at 10 non-Allegheny County coke plants in the United States and Canada were found to be at an excess risk of mortality from cancer of the lungs, bronchus, trachea, kidney, and prostate. An important finding of this study was the dose-response found by both length of exposure and intensity of exposure (top or side of the ovens) for mortality from cancer of the lungs, bronchus, and trachea. A study of Japanese coke oven workers also found them to be at an excess risk of lung cancer mortality. British studies of cancer mortality in coke oven workers have generally been negative, but there were weaknesses in these studies. Coke oven emissions produce positive results in mutagenicity studies. Coal tar, a condensate of coke oven emissions, and various constituents of coke oven emissions have been found to be positive in both mutagenicity and animal carcinogenicity studies.

***Feiner, B. "Health Hazards in Confined Spaces." Dangerous Properties of Industrial Materials Report, Vol. 2, No. 1, January-February 1982, p. 16. 82-004774. (EN)**

Despite safety procedures in confined space (CS) operations, many workers have been killed by hydrogen sulfide or methane in a sewer manhole, by carbon dioxide in ships' holds, by trichlorethylene vapor in degreasing tanks, or by lack of oxygen in grain silos. Hazard atmospheres encountered in a CS are the flammable, toxic, irritants and corrosives, and asphyxiants categories; effects of thermal hazards, noise, and vibration are also amplified in a CS. Safeguards for work in a CS are outlined under three broad categories; testing and preparation of the CS before entry, use of precautionary measures during occupancy, and assurance of prompt rescue and first aid in case of accident.

***Feiner, B. "Health Hazards in Confined Spaces: Part II." Dangerous Properties of Industrial Materials Report, Vol. 2, No. 2, March-April 1982, p. 219. 82-005582. (EN)**

Sources of contamination and other health hazards that can be found in an indoor environment are identified. Since some people may be indoor 70-80% of the time, exposure to contaminants can have serious health effects. Sources of contaminants identified include: gas stoves, tobacco smoke, furnaces, household cleaning substances, aerosol spray cans, bacteria, asbestos, and dust.

Freedman, T. "Warning: Staying at Home Can Be Dangerous to Your Health." Common Cause, Vol. 8, No. 3, June 1982, p. 13. (EN)

Many common household goods, appliances, and furnishings give off toxic chemicals and gases. Some of these indoor pollutants may prove to be a significant cause of illness, including respiratory disorders, nausea, skin irritations, and dizziness. High levels of indoor formaldehyde and potential carcinogens have been documented. Despite such mounting evidence, federal funds for relevant research are being slashed.

***Friberg, L. "Integrated Exposure Monitoring for Health Risk Assessment." Environmental Monitoring & Assessment, Vol. 2, No. 1-2, 1982, p. 7. (EN)**

Risk evaluation and estimation should be conducted for total exposure to pollution in ambient air, water, food, and industrial air, rather than separately for each pollutant. International programs aimed at estimating and evaluating risks are discussed. Better basic research in similar fields should increase health-related surveillance.

***Fugas, M., et al. "Study of Personal Exposure to Airborne Respirable Particles and Carbon Monoxide." Environmental Monitoring & Assessment, Vol. 2, No. 1-2, 1982, p. 157. (EN)**

Carbon monoxide and respirable particles (RP) were measured at outdoor network stations and compared to personal exposure of 12 volunteers to determine how well personal exposure can be assessed by the network stations. Personal exposure was in best correlation with home exposure, where the subjects spent about 70% of their time. Personal exposure to CO could not be related to outdoor levels, but exposure to RP was in agreement with outdoor concentrations measured in winter.

***Godish, T. "Formaldehyde and Building-Related Illness." Journal of Environmental Health, Vol. 44, No. 3, November-December 1981, p. 116. (EN)**

Formaldehyde contamination of indoor environments is studied. Field studies have linked formaldehyde with cancer, asthma, and other illnesses. Problems with mobile homes, urea-formaldehyde foam insulation, wood-frame housing, and non-residential buildings are discussed. Epidemiological studies are recommended to determine whether a causal relationship exists between environment and formaldehyde.

***Halbert, M.K., et al. "Inhalation Simulation and the Effects of Lung Environmental Conditions on Consumer Aerosol Products and NaCl Aerosol." Environmental Research, Vol. 29, No. 2, December 1982, p. 263. 83-003603. (EN)**

To assess the potential hazard associated with inhalation of commercial aerosol products, various cosmetic aerosols were studied with an apparatus that simulated the lung environment. The apparatus uses air heated and humidified to 37° C and 98% relative humidity, respectively. This apparatus, compared to earlier studies with nonsimulating equipment, shows a decrease in the proportion of larger particulates being inhaled. However, when the air was heated and humidified, all aerosols tested showed some growth in hygroscopic particulates.

***Health Aspects Related to Indoor Air Quality. World Health Organization, Copenhagen, 1979, EURO Report No. 21. (PA)**

It was recognized that indoor air quality depended on a number of factors operating simultaneously; these were examined separately and in relation to each other. The discussions took place in plenary sessions and meeting of 15 subgroups formed to consider different aspects of the problem. Both outdoor- and indoor-generated pollutants were analyzed. A number of recommendations were made for the development of research, for further evaluation of the existing data, for the formulation of guidelines on maximum concentrations of contaminants in indoor air, and for the limitation of emissions in the indoor environment.

***Hemminki, K., _et al_. "An Estimation of the Exposure of the Population in Finland to Suspected Chemical Carcinogens." _Journal of Environmental Science & Health-Env Carcinogenesis Reviews_, Vol. 1, No. 1, 1983, p. 55. 84-004957. (EN)**

A literature review was performed in an attempt to estimate the average total exposure of the Finnish population to known or suspected carcinogens. Sources of exposure considered are food, air, and water. Naturally occurring genotoxic compounds in food are discussed; the presence of mycotoxins, heavy metals, polycyclic aromatic hydrocarbons, pesticides, and food additives is also examined. The distribution of contaminants in drinking water and the home environment is addressed. Exposures attributable to lifestyles, such as intake of coffee or tea and prevalence of smoking, are evaluated.

***Honeywell Energy Products Newsrelease. "Indoor Air Could Pose Health Threat." April 11, 1984. 84-004528. (EN)**

The extent of indoor air pollution and consequent health effects are an emerging problems confronting health officials and researchers. Indoor air pollutants are emitted from cigarettes, appliances, furnishings, fabrics, and insulation. Pollutants of concern include carbon dioxide, formaldehyde, asbestos, ozone, radon, and nitrogen dioxide. Sophisticated control technologies to provide acceptable indoor air quality are under development. Air cleaners and absorption materials to block the recirculation of contaminants are being devised by researchers at Honeywell Inc.

"Indoor Air Pollutants: Exposure and Health Effects." World Health Organization, 1983, EURO Report No. 78. (EN)

Current knowledge about the sources and health effects of various indoor air pollutants is summarized. Important pollutants, such as carbon dioxide, carbon monoxide, ozone, radon, formaldehyde, and sulfur dioxide, are emitted by building insulation, gas or electrical appliances, and tobacco smoke. Low air exchange rates and poor ventilation aggravate indoor pollutant concentrations. Estimates of the fraction of people exposed to either high or low levels of each pollutant are analyzed. Health effects data are culled from recent animal toxicological, epidemiological, occupational, and control exposure studies.

Indoor Air Pollution: An Emerging Health Problem. NTIS, Springfield, VA, PB81-160087. (PA)

Traditionally it has been presumed that a person was protected from polluted air when indoors. Recent research has shown, however, that this may not always be true. Various harmful pollutants including radon, formaldehyde, and nitrogen dioxide have been found in the air in homes, offices, schools, and even in recreational facilities. The problem may even be made worse by Government energy conservation programs which encourage the "buttoning-up" of buildings. Federal efforts to deal with the problem have been piecemeal, receiving little support primarily because no one Federal agency has responsibility for the problem. Until responsibility is assigned to one agency to oversee the Federal efforts, they will continue to be ineffectual. In this report GAO recommends actions that the Environmental Protection Agency and the Congress can take to help resolve the situation.

***Last, J.A. "Health Effects of Indoor Air Pollution: Synergistic Effects of Nitrogen Dioxide and a Respirable Aerosol." Environment International, Vol. 9, No. 4, 1983, pp. 319-322. (PA)**

Comparative studies of the effects of various air pollutants on lung collagen biosynthesis have been performed. A hitherto unexpected synergism between the oxidant air pollutants ozone or nitrogen dioxide and a respirable-sized aerosol of ammonium sulfate was observed during controlled exposures of rats to these substances. In an assay system, measuring collagen biosynthesis by lung minces prepared from rats exposed for 1 week to either filtered air or to these pollutant gases, dose-response curves to either 0_3 or NO_2 are altered in the presence of 5 mg/m^3 of $(NH_4)_2SO_4$ aerosol. These observations may have broad implications for the appropriate evaluation of laboratory data in the setting of ambient air quality standards and/or the setting of threshold limit values for maintenance of occupational health and safety.

***Lebowitz, M.D. "Health Effects of Indoor Pollutants." Annual Review of Public Health, Vol. 4, 1983, p. 203-221.**

***Lebowitz, M.D. "Utilization of Data from Human Population Studies for Setting Air Quality Standards: Evaluation of Important Issues." Environmental Health Perspectives, Vol. 52, October 1983, p. 193. 84-002812. (EN)**

Epidemiological studies of community populations are quite useful in setting national ambient air quality primary standards. Unfortunately, the use of data from these studies is often problematic because of the difficulties of performing adequate community population studies. Important issues of appropriate exposure evaluation and health assessment are discussed, as are the problems of multiplex variables and colinearity.

*Lefcoe, N.M., *et al*. "The Health Risks of Passive Smoking." *Chest*, Vol. 84, No. 1, July 1983, p. 90-95.

*Lindberg, E., *et al*. "Chrome Plating: Symptoms, Findings in the Upper Airways, and Effects on Lung Function." *Archives of Environmental Health*, Vol. 38, No. 6, November-December 1983, p. 367. 84-003518. (EN)

Respiratory symptoms, lung function, and changes in the nasal septum were documented for 100 subjects exposed to chrome plating. ata were compared with those of 119 nonexposed controls as well as with data in the literature. Complaints of nasal irritation were common among subjects exposed to a daily average that exceed 1 mg/m^3 of chromic acid. The frequency of chronic bronchitis was similar to that in the control series. Nasal septal ulceration and perforation were observed in two-thirds of the subjects exposed to peak levels of 20 mg/m^3 or more. Both forced vital capacity and forced expired volume in one second were reduced by 0.2 L.

*Mage, D.T. *Possible Relationship of Sudden Infant Death Syndrome to Indoor Air Quality*. NTIS, Springfield, VA, EPA-600/D-84-193, July 1984. PB84-229830. (NT)

Sudden Infant Death Syndrome (SIDS) has been associated with higher rates of maternal smoking and higher body lead content of SIDS victims compared to control infants, matched for age and sex, who died of other causes. Hoppenbrouwers et al. demonstrated a temporal relationship between the seasonal pattern of SIDS (maximal in cold seasons, minimal in warm seasons) and the seasonal (winter) increase in ambient carbon monoxide (CO), nitrogen dioxide (NO$_2$), sulphur dioxide (SO$_2$), and lead (Pb) in Los Angeles County, California. Because infants in the first year of life spend most of their time indoors, and maternal smoking would add to the ambient levels in the home, it is the indoor levels of CO and Pb in the nursery that are of most immediate concern.

*McCarrol, J.R. "Health Costs of a Reduced Energy Supply." *Environmental Health Perspectives*, Vol. 52, October 1983, p. 255. 84-002816. (EN)

Although much attention has been directed to health effects associated with electricity production, virtually no attention has been paid to the health costs of a reduced or overpriced energy supply. Stringent emission control standards have raised the costs of producing energy, and although they have alleviated some health problems, further regulations will only increase production costs. These proposed regulations will most likely create new problems.

***Miller, S. "A Monitoring Report." Environmental Science & Technology, Vol. 17, No. 8, August 1983, p. 343A. 84-001650. (EN)**

The use of personal monitors for protecting workers from accidental exposure to chemicals, indoor air pollution, and various other occupational hazards is increasing. Personal monitors can be used in the laboratory to detect harmful levels of nitrogen dioxide, formaldehyde, sulfur dioxide, and respirable suspended particles. In the field, personal monitors detect concentrations of carbon monoxide, vinyl chloride, radon, organochlorine pesticides, and nonpolar volatile organic compounds.

National Cancer Institute. Carcinogenic Risk from Air Pollution by Engine Exhaust and Fuel Evaporation. NTIS, Springfield, VA, NCI/ICRDB/OK-84/05, August 1984. PB84-922905. (NT)

This ONCOLOGY OVERVIEW on the carcinogenic risk from air pollution by engine exhaust and fuel evaporation includes abstracts from the CANCERLIT data base, referencing articles published mainly from 1976 through mid-1983. The strategy used to retrieve these abstracts can be requested from the CIDAC office and entered on any MEDLARS/MEDLINE terminal system to update references in this area. This OVERVIEW encompasses epidemiologies, animal carcinogenicity and cell transformation studies, mutagenicity tests, metabolism studies, environmental levels, selected analytical techniques, and general reviews. The emphasis of the laboratory studies has been placed on 'real exhaust' samples. The search strategy used did not generate a comprehensive set of abstracts on work with pure components of engine exhaust, so the assessment of the included representatives of this type or work should be given less weight than the other studies. Tests of pure fuel additives were given relatively more coverage than pure exhaust components which also enter the same environment from other combustion processes.

***National Institute for Occupational Safety and Health. Development of Lung Surfactant Toxicological Tests. NTIS, Springfield, VA, 1984. PB84-240100. (NT)**

Studies on the properties of small airways and alveoli following respiratory disease in animals and tests for detection of lung disease in humans were conducted. Different types of experiments were conducted using trapped gases in isolated rat lungs. The stability of the small airways and alveoli was determined by placing an isolated rat lung into a plethysmograph which was placed into a larger chamber in which ambient pressure could be changed. Degassing was accomplished by oxygen absorption atelectasis using normal blood perfusion, followed by vacuum degassing after removal of the lung from the animal. A model was developed for gas trapping that included menisci formation within small airways, taking into account ratios of length of diameter as a function of lung inflation. In the plethysmograph, some gas was not in communication with the trachea and was trapped at maximum lung volume, mainly behind menisci or in foam or bubbles. The amount of gas trapped differed with different gases. The trapped gas was directly related to the solubility and molecular weight of the gas. The amount of fluid was an important factor.

***National Research Council. Asbestiform Fibers: Nonoccupational Health Risks. NTIS, Springfield, VA, ISBN-0-309-03446-9, February 1984. PB85-125516/XAB. (NT)**

The Committee considered the health risks posed by nonoccupational airborne exposures to asbestos and other natural or synthetic asbestiform fibers. The issue is important because many people may be exposed to these materials, although at relatively low levels. The EPA asked the NAS to undertake a study with two goals: to evaluate the human health risks associated with nonoccupational exposure to asbestiform fibers, with emphasis on inhalation of outdoor and indoor air; and to determine the extent to which the physical-chemical properties of the fibers may be associated with the development of various human diseases and the extent to which such information may be incorporated into assessing health risks resulting from exposure to the fibers. The Committee found that much more information is available about asbestos than about the other materials of concern. Nonoccupational exposure to asbestoform fibers in air present a risk to human health. The extent of the risk is highly uncertain, depending on the nature and amount of exposure and other factors. The Committee made several recommendations, e.g., systematic monitoring and characterization of asbestiform fibers with standardized methods should be undertaken in nonoccupational environments, including urban, rural, indoor, and outdoor locations where exposure may be of special concern; cessation of cigarette smoking should be encouraged.

National Technical Information Service. Formaldehyde. June, 1970-1984 (Citations from the NTIS Data Base). Report for June 1970-1984, NTIS, Springfield, VA, December 1984. PB85-852366/XAB. (NT)

This bibliography contains citations concerning the health hazards of formaldehyde inhalation. Health hazard evaluation reports of industrial sites are discussed and the effects of formaldehyde on animals and humans are considered. Industrial hygiene sampling method and analytical methods to quantitate formaldehyde are also discussed.

Nicholson, W.J. **Draft Asbestos Health Assessment Update. NTIS, Springfield, VA, EPA-600/8-84-003A, February 1984. PB84-186832. (NT)**

Data developed since the early 1970's from large population studies with long follow-up strengthen the correlation of asbestos exposure with disease. Lung cancer and mesothelioma are the most important asbestos-related causes of death among exposed individuals. The accumulated data suggest that the excess risk of lung cancer from asbestos exposure is proportional to the cumulative exposure (the duration times the intensity) and the underlying risk of lung cancer in the absence of exposure. The risk of death from mesothelioma appears to be proportional to the cumulative exposure to asbestos in a given period. Animal studies confirm the human epidemiological results. All major asbestos varieties produce lung cancer and mesothelioma with only limited differences in carcinogenic potency. Some measurements demonstrate that significant asbestos exposure, exceeding 100 times the background, occurs to individuals in non-occupational environments. Currently, the most important of these non-occupational exposures is from the release of fibers from asbestos-containing surfacing materials in schools, auditoriums, and other public buildings or from asbestos fireproofing sprayed in high-rise office buildings.

***OECD Report.** **Environmental Effects of Energy Systems: The OECD Compass Project. 1983. 84-004384. (EN)**

The OECD Compass Project seeks to document the environmental implications of various energy end-uses. Comparative assessment methodologies are applied to analyses of commercial and residential building heating and cooling systems. Gaseous, liquid, and solid residues generated by space heating systems in Fredericton, New Brunswick, are discussed; analysis of energy use scenarios developed for 1990 and 2000 show that adoption of extensive energy conservation measures could improve environmental quality. Similar regional or national fuel mix and environmental impact scenario evaluations are performed for energy systems in the Netherlands Rijnmond region. Environmental analysis and least cost energy models are applied to the U.S. energy structure.

***Otson, R., et al. "Survey of Selected Organics in Office Air." Bulletin of Environmental Contamination and Toxicology, Vol. 31, August 1983, p. 222. (EN)**

To aid in the health hazard assessment of organic compounds in office air, 30 such workplaces in Canada were surveyed for potential sources. The air levels of selected volatile organic compounds were determined. Important sources of detected compounds were tobacco smoke, typewriter fluids, copy machine chemicals, and cleaning solvents. Levels of dichloromethane, tetrachloroethylene, and toluene are tabulated, and detection limits for monitoring and analytical devices are considered.

***Porter, G. "A Sample a Day. . .Personal Monitors of Pollutants." Dimensions (NBS), Vol. 65, No. 1, January-February 1981, p. 8. 81-001205. (EN)**

Indoor air pollution is receiving increased attention as the effects of individual pollutant exposure are being investigated. Individual exposure levels can be useful in the regulatory process and in verifying the levels at which pollutants cause health problems. Passive and active personal sampling monitors have been developed to collect nitrogen oxides and particulates. The design features of these devices are described.

"Proceedings of the Symposium on Health Aspects of Indoor Air Pollution." Bulletin of the New York Academy of Medicine, Vol. 57, No. 10, December 1981, p. 825-1086.

***Repace, J.L., et al. "Indoor Air Pollution, Tobacco Smoke, and Public Health." Science, Vol. 208, No. 4443, May 2, 1980, p. 464-472. (ME)**

An experimental and theoretical investigation is made into the range and nature of the exposure of the nonsmoking public to respirable suspended particulates from cigarette smoke. A model incorporating both physical and sociological parameters is shown to be useful in understanding particulate levels from cigarette smoke in indoor environments. Observed levels of particulates correlate with the predictions of the model. It is shown that nonsmokers are exposed to significant air pollution burdens from indoor smoking. An assessment of the public health policy implications of these burdens is presented.

***Robertson, B.E., et al. "Societal Valuation of Human Life as Manifested by Use or Non-use of Air Heat Exchangers." ISES/Solar Energy Society of Canada Energex 8th Conference, Vol. 1, August 23-29, 1982, p. 39. 84-003993. (EN)**

To provide information on risk for use by laymen, it is useful to estimate the implied value of human life associated with actions taken to minimize risk. Estimates are made of the risk accompanying the enhancement of indoor radon-daughter levels resulting from measures taken to conserve energy in home heating as practiced in Saskatchewan, Canada. The value imputed for a human life as a result of decisions to install air-to-air heat exchangers solely for the purpose of minimizing risk is analyzed. This value is compared with others implied by measures to improve health care and highway safety and is found to be similar.

***Salter, R.G., House Committee on Government Operations Hearings. Federal Response to Health Risks of Formaldehyde in Home Insulation, Mobile Homes, and Other Consumer Products. May 18-19, 1982. 83-004941. (EN)**

Hearings were convened to examine the federal response to reports of formaldehyde-related health problems from consumer products. The health effects and economic consequences of formaldehyde in home insulation and in mobile homes are emphasized. The adequacy of a ban on formaldehyde imposed by the U.S. Consumer Product Safety Commission was debated. Testimony was provided by Philip Abrams representing HUD; ORNL Biology Div. Director Richard A. Griesemer; Rep. John J. LaFalce (D-NY); and others. Associated documents and memoranda are transcribed.

Sangster, B., et al. "Non-occupational Exposure to Pentachlorophenol: Clinical Findings and Plasma-PCP-Concentrations in Three Families." Human Toxicology, Vol. 1, No. 2, March 1982, p. 123. (EN)

Clinical findings are reported for 15 members of three families living in houses where relatively large amounts of pentachlorophenol (PCP) solutions had been applied. Plasma PCP concentrations were measured in the subjects. No signs of systemic PCP intoxication were observed; however, several symptoms of skin disorders were documented, possibly caused by a direct influence of airborne PCP.

***Selikoff, I.J. "Twenty Lessons from Asbestos." EPA Journal, Vol. 10, No. 4, May 1984, p. 21. 84-005751. (EN)**

Occupational and non-occupational exposures to asbestos over the last 60 years are manifest in the widespread incidence of related diseases. There have been more than 100,000 deaths related to this mineral, and another 350,000 are anticipated before the effects of past exposures have run their course. The observation of so much serious disease has led to increased understanding of the circumstances in which it has occurred. Lessons learned from past asbestos exposure concern theories of latency, dose-disease response, multiple factor interaction, disease with brief exposure, environmental persistence, limitations of epidemiology, and other concepts and facts.

***Sexton, K., et al. "Estimating Human Exposure to Nitrogen Dioxide: An Indoor/Outdoor Modeling Approach." Environmental Research, Vol. 32, No. 1, October 1983, p. 151. 84-000732. (EN)**

Adverse health effects associated with human exposure to nitrogen dioxide are well documented. To assess health risks and implement effective control strategies, accurate data are required concerning the number of people exposed and patterns of exposure. Central monitoring data is not always reliable, as many people now spend time indoors and away from fixed monitors. A simple deterministic model is DE exposure. Exposure is related to background values, indoor levels, and human activities. Results suggest that indoor NO_2 levels in private dwellings vary with outdoor concentrations and type of cooking fuel or appliance.

***Spengler, J.D., et al. "Indoor Air Pollution: A Public Health Perspective." Science, Vol. 221, No. 4605, July 1, 1983, p. 9-17. (ME)**

Although official efforts to control air pollution have traditionally focused on outdoor air, it is now apparent that elevated contaminant concentrations are common inside some private and public buildings. Concerns about potential public health problems due to indoor air pollution are based on evidence that urban residents typically spend more than 90 percent of their time indoors, concentrations of some contaminants are higher indoors than outdoors, and for some pollutants personal exposures are not characterized adequately by outdoor measurements. Among the more important indoor contaminants associated with health or irritation effects are passive tobacco smoke, radon decay products, carbon monoxide, nitrogen dioxide, formaldehyde, asbestos fibers, microorganisms, and aeroallergens. Efforts to assess health risks associated with indoor air pollution are limited by insufficient information about the number of people exposed, the pattern and severity of exposures, and the health consequences of exposures. An overall strategy should be developed to investigate indoor exposures, health effects, control options, and public policy alternatives.

***Spengler, J.D., et al. "Long-term Measurements of Respirable Sulfates and Particulates Inside and Outside Homes." Atmospheric Environment, Vol. 15, No. 1, 1981, p. 23. 81-001434. (EN)**

To better understand the health effects of air pollution, the results of extensive indoor and outdoor measurements of mass respirable particulates and water-soluble respirable particulates are analyzed. The measurements were taken in six U.S. cities -- Portage, WI; Topeka, KA; Kingston/Harriman, TN; Watertown, MA;

St. Louis, MO; and Steubenville, OH. Results indicated that the major source of indoor air pollution is cigarette smoke, which contributes about 20 mg of indoor particulate matter/m^3/smoker. In all cities, indoor respirable sulfate concentrations were consistently lower than outdoor concentrations were.

***Stock, D.J., et al. "Exposure Estimates for the Houston Area Asthma Study." Environmental Monitoring & Assessment, Vol. 2, Nos. 1-2, 1982, p. 129. (EN)**

Residential clusters of asthmatics in the Houston area were studied to determine the health effects of air pollution on the Texas Gulf Coast region. Air pollutant monitoring data from centrally-located fixed stations, residential areas, and personal testing were used. Fixed and mobile sites monitored ambient levels of ozone, nitrogen oxides, sulfur dioxide, carbon monoxide, and meteorological parameters. Sequential integrated samplings were done for total suspended particulates and inhalable particulates.

***Swedish Council for Building Research. Indoor Air. Volume 1. Recent Advances in the Health Sciences and Technology. Proceedings of the International Conference (3rd) on Indoor Air Quality and Climate Held in Stockholm on August 20-24, 1984. NTIS, Springfield, VA, ISBN-91-540-4191-O; D16:1984, 1984. PB85-104180/XAB. (NT)**

Contents: Future buildings and building hygiene. Sick building syndrome. Lung cancer from radon and passive smoking. Total exposure estimation. Health implications of indoor air humidity. Indoor odors. Indoor allergens. Effect of moderate thermal stress and evaluation of thermal discomfort. Airborne infections and modern building technology. Free radicals and oxidizing agents in the indoor air. Air quality control strategies. Achievement of the super-clean environment. Policy and regulatory issues.

***Swedish Council for Building Research. Indoor Air. Volume 3. Sensory and Hyperreactivity Reactions to Sick buildings. Proceedings of the International Conference (3rd) on Indoor Air Quality and Climate Held in Stockholm on August 20-24, 1984. NTIS, Springfield, VA, ISBN-91-540-4195-3; D18; 1984. PB85-104180/XAB. (NT)**

Contents: Formaldehyde, Sources, exposures, measurements and health effects. Air ions and electrical fields. Allergies and other hypersensitivity reactions to indoor pollutants. Microorganisms related to buildings. Sick buildings; physical and psychosocial features, effects on humans and preventive measures. Odors and sensory irritants; Effects on health and comfort.

***Thun, M.J., Lakat, M.F., et al. "Symptom Survey of Residents of Homes Insulated with Urea-Formaldehyde Foam." Environmental Research, Vol. 29, No. 2, December 1982, p. 320. 83-003604. (EN)**

This is a report to assess the health effects of urea-formaldehyde (UF) upon people whose homes had been insulated with the substance. A retrospective cohort study, through use of a standard questionnaire administered through telephone interviews, was undertaken. Control homes were selected from neighboring houses. First, structural problems and odors resulting from UF installation were examined. Questions concerning health were next administered. The findings indicate no broad based epidemiology of allergic or irritative symptoms, but excessive instances of burning skin and wheezing or breathing difficulty.

***Wallace, L.A. "Carbon Monoxide in Air and Breath of Employees in an Underground Office." Air Pollution Control Association Journal, Vol. 33, No. 7, July 1983, p. 678. 84-000795. (EN)**

Employees working in an undergound office were monitored to determine the carbon monoxide levels in their breath. The office was discovered to have 8-hour average CO concentrations of 18-26 ppm during one week in winter. On one afternoon, 20 nonsmoking workers -- out of a total of 65 people working in the office -- had alveolar CO levels of 23.3 ppm compared with levels of 8.2 in six nonsmoking workers in other offices within the same building. When these same workers were out of the office during the weekend, their alveolar CO levels dropped dramatically. A parking garage on the same level as the office was the reason for the elevated CO levels in the environment.

Weiss, S.T., et al. "The Health Effects of Involuntary Smoking." American Review of Respiratory Diseases, Vol. 128, No. 5, November 1983, p. 933-942. (ME)

Involuntary smoking is defined as the exposure of nonsmokers to tobacco combustion products in the indoor environment. Involuntary smokers are exposed to a quantitatively smaller and qualitatively different smoke exposure than active smokers. Quantitation of exposure is particularly difficult in both physiologic and epidemiologic studies. Acute physiologic studies have documented minimal physiologic changes in healthy subjects. However, individuals with heart or lung disease may be differentially affected. A relatively large body of data relates parental (particularly maternal) cigarette smoking to the occurrence of both acute respiratory illnesses and chronic respiratory symptoms in children. The effect seems to be greatest early in life and cannot be separated from in Utero exposure. Data linking parental smoking to lower levels of pulmonary function are all cross-sectional and less conclusive.

What is apparent is that the magnitude of the direct effect of passive smoke exposure is likely to be relatively small (from 1 to 5% reduction in maximally obtained lung function level in exposed children). Data on adults are insufficient to allow for a quantitative estimate. The important effects of passive smoke exposure in childhood are twofold. The slight reduction in pulmonary function level may predispose individuals to increased risks from environmental agents later in life. In addition, having a parent who smokes substantially increases the likelihood that a child will become a smoker. Finally, two studies have linked lung cancer in nonsmokers to exposure to spouses' cigarette smoke. Further research is needed to confirm these findings. Involuntary smoking may have important health effects, either direct or indirect, which deserve further study.

***White, J.R., et al. "Small-Airways Dysfunction in Non-Smokers Chronically Exposed to Tobacco Smoke." New England Journal of Medicine, Vol. 302, No. 13, March 27, 1980, p. 720-72?. (ME)**

We evaluated the effect of long-term passive smoking (involuntary inhalation of tobacco smoke by nonsmokers) and long-term voluntary smoking on specific indexes of pulmonary function in 2100 middle-aged subjects. Regardless of sex, nonsmokers chronically exposed to tobacco smoke had a lower forced mid-expiratory flow rate (FEF 25 to 75 per cent) and forced end-expiratory flow rate (FEF 75 29 85 per cent) than nonsmokers not exposed (p less than 0.005). In addition, values in passive smokers were not significantly different from those in light smokers and smokers who did not inhale (p less than 0.005). When we looked at the extent to which smoke exposure is related to graded abnormality, we found that nonsmokers in smoke-free working environments have the highest scores on the spirometric tests; passive smokers, smokers who do not inhale, and light smokers score similarly and significantly lower; and heavy smokers score the lowest (p less than 0.005). We conclude that chronic exposure to tobacco smoke in the work environment is deleterious to the nonsmoker and significantly reduces small-airways function.

World Health Organization. "Estimating Human Exposure to Air Pollutants." WHO Report 69, 1982. (EN)

The state of the art of air pollution exposure monitoring is reviewed, and widely accepted techniques for use in monitoring and identifying pollutants are critiqued. Exposure is defined as the amount of contact between an air pollutant and inner or outer surface of the human body; dose, on the other hand, is the amount of air pollutant crossing one of the body boundaries. Factors influencing indoor air pollution concentrations are evaluated, as are the effects of population mobility and socioeconomics on air pollution.

World Health Organization. "Evaluation of Exposure to Airborne Particles in the Work Environment." WHO Report 80, 1984. (EN)

Occupational exposure to airborne particles is common and frequently poses a potential hazard to human health. The nature and properties of aerosols found in the work environment are summarized. Information and guidance is provided for personnel involved in planning and implementing occupational hygiene or air sampling/analysis programs. A rationale for sampling either total particles or respirable particles is delineated, with emphasis on their relationship to potential adverse health effects following inhalation. Principles of particle collection and instruments currently in use are addressed.

***Young, G.S., Hagopian, J.H., *et al*. "Potential Health Effects of Residential Energy Conservation Measures." NTIS, Springfield, VA, PB82-133315, July 1981. 82-005445. (EN)**

Health effects of residential energy conservation techniques were assessed. Annotated biographies for indoor air quality, indoor air pollution health effects, and residential air filtration are included. Air filtration data is presented. Factors related to the house, the residents, the microenvironment, and their interrelationship are discussed.

IV. MEASURES TO MITIGATE INDOOR AIR POLLUTION

Amercian National Standards Institute/Americian Society of Heating, Refrigerating, and Air Conditioning Engineers. ANSI/ASHRAE Standard 62-1981: Ventilation for Acceptable Indoor Air Quality. New York, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., 1981.

***Bozzelli, Joseph W., et al. Airborn Asbestos Levels in Several School Buildings Before and After Bulk Asbestos Removal." International Journal of Environmental Studies, Vol. 20, 1982, p. 27. (EN)**

Airborne particulate samples were collected in several public schools before and after friable asbestos-containing insulation material had been removed from ceilings. Transmission electron microscopy with selected area electron diffraction techniques facilitated fiber identification and counting. Asbestos fibers concentrations in indoor air were in the range 5-40 ng/m^3 before insulation removal. Measurements made one week after removal showed reductions of 56-90%. (18 references, 1 table)

***Fletcher, R.A., et al. "The NBS Portable Ambient Aerosol Sampler." EPA Pollutant Monitoring of Ambient Air & Stationary Sources Symposium. Raleigh, NC, May 4-7, 1982. 84-002847. (EN)**

A portable, battery-powered particle sampler for collecting ambient level concentrations of respirable particles has been developed at NBS. The unit has a flow rate of 6 L/minute and can operate for 24 hours or more on a single battery charge. It separates and collects the ambient inhalable particulate size fractions by series filtration. The sampling protocol is well suited for indoor particulate monitoring and is also useful for nitrogen dioxide monitoring.

***Fisk, W.J., et al. Ventilation for Control of Indoor Air Quality. NTIS, Springfield, VA, LBL-17597; CONF-840803-3 Feb. 1984. DE84015997/XAB. (NT)**

Ventilation is widely used to help maintain acceptable indoor pollutant concentrations. In this paper, the relationships between ventilation rate and indoor concentration are examined by the use of mass balance models and measured data. It is shown that the pollutant source strength and pollutant removal by processes other than ventilation can have a large impact on the indoor concentration and that maintenance of a typical ventilation rate does not ensure an acceptable indoor concentration. The importance of avoiding unusually low ventilation rates and of minimizing pollutant source strengths is emphasized.

***Hanson, David J., et al. "Effects of Foam Insulation Ban Far Reaching." Chemical & Engineering News, Mar. 29, 1982, P34. 82-005555. (EN)**

When the U.S. Consumer Product Safety Commission voted in February 1982 to ban the use of urea-formaldehyde foam insulation in schools and homes, it made one of the most far reaching and controversial decisions in the agency's history. The ban was implemented due to evidence revealing health hazards of this type of insulation, including eye irritation and the possible carcinogenicity of insulation emissions. The Economic Impact that this ban may have on related industries is discussed.

***Hinds, William C., et al. "Control of Indoor Radon Decay Products by Air Treatment Devices." Air Polution Control Association Journal, Vol. 33, No. 2, February 1983, p. 134 (3). 82-005555. (EN)**

Research was conducted to determine the most efficient devices for control of indoor radon decay products by air treatment devices. Box fans, ceiling fans, electrostatic precipitators, and filters were tested. Room size air cleaners can achieve substantial reductions in working levels in residences. Reductions observed at air infiltration rates of 0.52 air changes per hour ranged from 58-89%. The ceiling fan appears the most suitable for residences.

***Kirsch, L.S., et al. "Behind Closed Doors: Indoor Air Pollution and Government Policy." Harvard Environmental Law Review, Vol. 6, No. 2, 1982, pp. 339-398. (PA)**

This article examines the problems of indoor air pollution and the policy options it presents. Part I discusses the individual pollutants, their known concentrations inside homes, the health problems they pose, and possible methods of controlling them. Part II examines the potential for applying three currently existing federal statutes to the regulation of indoor air pollution. Part III discusses the need for an expanded governmental role in the control of indoor air pollution, evaluates the possible strategies which Congress might consider, and presents a proposal for federal legislation.

***Kirsch, Laurence S. "Indoor Air Pollution and Government." Environment. Vol. 25, No. 3, April 1983, p. 26. (EN)**

The current authority for the regulation of indoor air pollution in residential settings is examined, and the types of government action that could be taken are compared. Legislation is proposed that Congress should adopt to ensure that further research is undertaken, that the results of the research are rendered useful to the average citizen, and that future federal efforts in this area be well coordinated. Profiles of the Clean Air Act of 1977, Toxic Substances Control Act of 1976, Nat'l Ambient Air Quality Standards, Nat'l Emission Standards for Hazardous Air Pollutants, EPA activities under the Toxic Substances Control Act, and the Consumer Product Safety Act of 1973 are provided.

***Liiri, Osmo, et al. "Painting as a Preventive of Formaldehyde Emission from Particle Board." Finland Technical Research Centre Report 190, 1983. 84-001423. (EN)**

Formaldehyde emissions from particle board used in residential construction were characterized. The use of paints to seal the particle board and thereby reduce such emissions was investigated. Reactive and latex paints were tested for this purpose. Results revealed that painting reduced the formaldehyde content of air to levels below 0.15 mg/m^3. (In Finnish) (4 diagrams, 5 graphs, 2 photos, 5 references, 10 tables)

***Males, Rene. "R&D Status Report; Energy Analysis and Environment Division." EPRI Journal, Vol. 8, No. 4, May 1983, p. 48. 84-000010. (EN)**

DOE and a number of electric utilities conducted 14 experiments involving time of use rates for residential customers during 1975-81. If such data on customer response patterns can be transferred across geographic regions, many utilities may be able to avoid conducting expensive, time-consuming experiments. EPRI is investigating such trasnferability issues, and data from DOE studies are being used in the development of an econometric transferability model for predicting residential load response to time of use rates. Indoor air pollution research initiated by EPRI has shown that energy conservation efforts that reduce infiltration of outside air serve to increase the concentration of air pollutants in homes. Mass balance algorithms for predicting indoor pollutant concentration as a function of outside pollutant levels are being developed.

***Martinex, K.F. Control Technology for Fermentation Processes: Walk-Through Survey Report of Miles Laboratories, Inc., Elkhart, Indiana. NTIS, Springfield, VA, CT-116-16A, Mar. 1984. PB84-243518. (NT)**

A walk through survey to assess control technology at the enzyme production facility of Miles Laboratories, Incorporated (SIC-2869), Elkhart, Indiana, was conducted in July 1983. The enzyme production operation was essentially a closed system. The facility maintained a clean occupational environment and good work practices. Although the health program was maintained at the corporate level, the facility was in the process of developing a procedure for detecting trace quantities of enzymes in the ambient air. Preplacement and selected periodic medical evaluations were performed. Personal protective equipment was used when potentially hazardous operations were performed.

***Matthews, T.G., et al. "Formaldehyde Surface Emission Monitor" EPA Pollutant monitoring of Ambient Air & Stationary Sources Symposium, Raleigh, NC, May 4-7, 1982. P30. 84-002841. (EN)**

A formaldehyde surface emission monitor is under development for the passive, non-destructive measurement of CH20 emission rates from flat surfaces. The apparatus uses a solid sorbent and a 13x molecular sieve that provides excellent chemical stability for sorbed CH20 and permits the monitor to be used in any physical orientation. With a 0.032 m^2 test area, a 0.01 mg CH20/m^2/hour detection limit can be achieved with a 3 hour sampling period. Preliminary test results indicate the device could be used for quality control measurements of commercial CH20 resin-containing materials, and in situ measurements from various sources in domestic environments.

Measurement and Monitoring of Non-criteria (Toxic) Contaminants in Air. Air Pollution Control Association Measurement & Monitoring of Non-criteria (Toxic) Contaminants in Air Symposium Proceedings. Chicago, Mar. 22-24, 1983. (EN)

Current methods for sampling and analysis of toxic contaminants in air are state-of-the-art, complex, and costly. The measurement problem is a stumbling block to implementation of air quality regulations. Topics discussed in APCA's specialty conference on measuring non-criteria pollutants include: the chemical industry's position on hazardous air pollutants, ambient air around abandoned check waste dump sites, sampling organic compounds near a hazardous liquid surface impoundment, toxic, organic air pollutants in the arctic, survey of eight states' local toxic control strategies, air pollutants from industrial boilers, screening for polynuclear aromatic hydrocarbons, total reduced sulfur emission testing, asbestos sampling, field testing of hazardous waste incinerators, indoor air pollution, and PCB waste destruction.

***Mirabella, Vince A. "On a Clear Day." Clean Air-Australia, V16, N1, February 1982, P11. 82-004685. (EN)**

A major restructuring in approach and organization of U.S. regulatory agencies is currently in progress. Multimedia assessments that consider all potential ecological impacts are being considered as a means for treating air, water, and solid waste problems together. Reauthorization of the Clean Air Act, will most probably emphasize the need for transferring responsibility for complying with the act to individual states that are most aware of local conditions and values.

***Morrill, Elizebeth. "Indoor Air Pollution and Some Solutions." Wood N Energy, Vol. 2, No. 12, December 1982, p. 30. 83-004207. (EN)**

While homeowners have been weatherstripping and insulating their houses, researchers have discovered that such activities serve to seal in potentially dangerous pollutants that normally escape through window and door cracks. One frequent source of indoor air pollution is the fireplace, along with wood and coal-burning heaters. Particulates and carbon monoxide are emitted by these systems. Kerosene heaters, gas appliances,and insulating materials are also culprits of indoor air pollution. Air cleaning appliances, increased ventilation, and the use of air-to-air heat exchanges can help purify indoor air.

***Mortimer, Jr., V.D. In Depth Survey Report: Control Technology for Formaldehyde Emissions at Hillcrest Veneer Plant, High Point, North Carolina. NTIS, Springfield, VA, CT-108-136, 6 Jan. 1984. PB84-199884. (NT)**

A survey to assess the techniques used to control occupational exposure to formaldehyde (50000) was conducted at the Hillcrest Veneer Factory (SIC-2435, S:IC-2436), High Point, North Carolina, in September 1982. The control systems at the facility were found to be effective. The low concentrations were achieved by combination of an area and local exhaust ventilation system that exhausted 93,000 cubic feet per minute (cfm) air from the press room, with a supply air system that infused approximately 18,000 cfm fresh air into the primary work area of the press workers. The author suggests that research be done to determine the optimal configuration of the fresh air outlets. The control system at this facility is efficient.

Special Investigation Report - An Evaluation of the Garrett TPE 331 Engine's Potential for Turbine Oil By-Product Contamination of an Aircraft Cabin Environmental System. National Trasportation Safety Board, Washington, D.C. Bureau of Technology. NTIS, Springfield, VA, NTSB/SIR-84/01, 20 Jan. 1984. PB84-917006/XAB. (NT)

A hypothesis presented to the National Transportation Safety Board investigator during several accident investigations caused the Safety Board to examine the possibility that a cracked front mainshaft compressor carbon seal element used in the Garrett TPE-331 turboprop engine might allow engine oil to leak through the carbon seal, enter the engine's airflow, pass through the compressor bleed air systems, and allow toxic or anesthetic byproducts of the oil to enter the aircraft's cabin environmental system. Further, the hypothesis suggested that the toxic or anesthetic gases, if any, might adversely affect the flightcrew's capacity to control the aircraft during critical phases of flight. And finally, it was hypothesized that the potential for a safety hazard could extend to all turbine engines using synthetic turbine oil and supplying compressor bleed air for aircraft cabin environmental control. To test the validity of the hypothesis, the Safety Board formed an ad hoc Special investigative committee. The committee received technical support from manufacturers, consultants, and other governmental agencies. These included the Federal Aviation Administration's Civil Aeromedical Institute, Clayton Environmental Consultants, Inc., the Department of Energy, the Environmental Protection Agency, Exxon Research and Engineering Company, and the Garrett Turbine Engine Company. The contributions of these organizations included the technical expertise for formulating the tests and the analysis of the test results. As a result of the investigation, the Safety Board has concluded that contamination of compressor bleed air by the ingestion of engine oil is not possible.

***Nero, Anthony V. Indoor Radiation Exposures From Radon and Its Daughters: A View of the Issues. LBNL Report LBL-10525, Aug. 1981. 82-004441. (EN)**

Current knowledge of indoor radon concentrations, their associated health risks, and energy-saving measures that reduce ventilation rates is reviewed. Conservation programs could be adjusted to achieve both energy savings and acceptable indoor air quality. Indoor air quality standards could be developed to protect individuals from excessive radon exposure; building standards to control average exposures could help implement prospective air standards.

***O'Brien, D.M., et al. Control Technology for New Materials at International Harvester, Columbus Plastics Plant, Columbus, Ohio. NTIS, Springfield, VA, CT-148-16, Aug. 1984. PB85-103539/XAB. (NT)**

Area and breathing zone samples were analyzed for styrene (100425) at the plastics factory of International Harvester (SIC-3713), Columbus, Ohio, on April 10, 1984. Engineering controls were inspected. At the request of the union health and safety representative, a spray booth where an asbestos (13332214) containing sound muffler had been sprayed was inspected. The authors note that the placement of the pedestal fan in the press room may contribute to worker exposure to styrene. They conclude that engineering controls are well developed in some areas, but not in the press room area. They recommend placing a fresh air shower above the press operators' work stations and developing dust controls for small tools such as saws, drills, grinders, and sanders.

Pedersen, B.S., et al. Air Washing for the Control of Formaldehyde in Indoor Air. NTIS, Springfield, VA, LBL-16822: CONF-840803-5, Feb. 1984. DE84015994/XAB. (NT)

Formaldehyde is a common indoor air pollutant that is difficult to control. One potentially suitable control technique for indoor formaldehyde is air washing: the absorption of formaldehyde by a liquid. This report presents a mathematical model of an air washer, describes tests of two air washers, and compares the energy required for controlling formaldehyde concentrations by ventilation and by air washing. The two experimental air washers tested employ water as the washing liquid and incorporate a refrigeration system to control the humidity of the outlet airstream. Air flow rates through the air washers were 100 to 160 l/s and inlet formaldehyde concentrations were 80 to 480 ng/l. The formaldehyde removal efficiencies of the two designs were 0.36 to 0.47 and 0.30 to 0.63. Results show that an air washer with reasonable power and water requirements can effectively remove formaldehyde from indoor air.

***Riley, Richard L. "Indoor Spread of Respiratory Infection by Recirculation of Air: A Controllable Hazard." Presented at Society for Occupational & Env Health (Ann Arbor) Conference, Salt Lake City, Apr. 4-7, 1979, P653. 82-002056. (EN)**

Insulation and air recirculation conserve energy, and also increase the likelihood of airborne infection as recirculation prevents dilution of airborne organisms with outdoor air. Preventing infection by recirculated organisms is possible in several ways. Germicidal ultraviolet radiation and disinfection techniques are described.

***Salter, R.G.. Indoor Air Quality Handbook for Designers, Builders, and Users of Energy Efficient Residences. US Sandia Natl Labs Report SAND82-1773, Sep. 1982. 83-004939. (EN)**

A handbook has been compiled to assist designers, builders and users of energy-efficient residences to achieve energy efficiency and maintain high indoor air quality. Potential problems of indoor air pollution are identified and possible solutions are discussed. The effects of a building system on indoor air quality, the health effects of specific air contaminants and the health standards developed for them, methods for predicting and measuring contaminants and evaluating human response, methods for the control of indoor air pollution once contaminants have been identified, and the legal aspects of indoor air quality are among the topics addressed.

***Sinha, J.K., et al. "Industrial Ventilation System and its Application in Pollution Control in Industries." Indian Journal of Environmental Protection, Vol. 3, No. 4, October 1983, p. 116. 84-004202. (EN)**

Industrial ventilation systems reduce workers' exposure to airborne contaminants. Air movement is the prime factor in operating an effective ventilation system. Ventilation system requirements for pollution control are discussed. Dilution, source control and exhaust, and clean air supply ventilation approaches are considered.

***Spengler, John D., et al. "The IN's and OUT's of Air Pollution." Technology Review. Vol. 85, No. 6, August-September 1982, p. 32. 83-000024. (EN)**

Federal Regulations on air quality as defined by the Clean Air Act of 1970 vary little with regard to region or situation. Each area of the U.S. must now devise ways to meet air-quality standards, even when the types of pollutants vary from area to area. The relationship between indoor air quality and health is also explored; although few studies have been undertaken, concentrations of harmful pollutants are known to be higher in indoor environments.

***Swedish Council for Building Research. Indoor Air. Volume 5. Buildings, Ventilation and Thermal Climate. Proceedings of the International Conference (3rd) on Indoor Air Quality and Climate Held in Stockholm on August 20-24, 1984. NTIS, Springfield, VA, 1984. PB85-104222/XAB. (NT)**

Contents: Technical solutions to providing adequate indoor air quality and thermal climate, ventilation efficiency, air cleaning devices, design concepts, ventilation criteria: biological demands and formulation of standards for specific environments and specific compounds; indoor thermal climate: requirements for comfort, health and performance, instrumentation, and building performance assessment with respect to ventilation as well as air quality.

***Turk, A. "Gaseous Air Cleaning to Maintain Tolerable Indoor Air Quality Limits." ASHRAE Transactions, Vol. 9, No. 1B, 1983, p. 505. 84-005666. (EN)**

Gaseous air cleaners considered most effective for indoor applications consist of granular adsorbents with or without special impregnations. The nonpolar adsorbent of choice is activated carbon; polar adsorbents include activated alumina, silica gel, and surface-active clays. An air sampler comprised of 16 cylindrical cartridges manifolded in a 4 x 4 pattern is described. The device can be used in any of three modes: to test a given adsorbent for its service life in any indoor environment; to set up competitive tests between different adsorbents; and to test a partially saturated adsorbent for its residual efficiency.

***Turpin, J.L. Hydrocarbon Solvent Recovery in the Presence of Resin Contaminants. NTIS, Springfield, VA, EPA-600/2-84-003, Jan. 1984. PB84-148170. (NT)**

A system was developed to recover acetone from an air stream in which there were suspended epoxy resin particles. This recovery problem is encountered in the manufacture of fiber glass reinforced plastic pipe. It is representative of numerous other industrial situations which require the recovery of hydrocarbon solvents from a gaseous stream containing resin particles in order to eliminate atmospheric pollution. The system developed was a three-stage low temperature condensation process proceded by a cascade impactor. A scale model of the system was designed and constructed. It was tested in the laboratory, and on a split stream of an actual plant process.

Wayman, J.L., et al. Effect of Sealants on the Sound Absorption Coefficients of Acoustical Friable Insulating Materials (Technical rept. 1 Nov. 83-30 Sep. 1984). NTIS, Springfield, VA, NPS-53-85-004, Oct. 1984. AD-A148 541/6/XAB. (NT)

Acoustical friable insulating materials (AFIM), which often in the past contained asbestos, have been used for sound control since the mid-1930's. Because of their widespread use and the ease of fiber dissemination, friable asbestos materials are considered to be the major source of asbestos fiber contamination in the indoor environment. Encapsulation of asbestos materials with a commercial sealant product is one of several methods used to control potential asbestos exposure in rooms. A sealant product that preserves most of the acoustical properties of the material is preferred in this usage. AFIM sample materials were treated with 6 types of sealants and the effects on normally incident absorption coefficients from 100 to 2500 Hz were measured using a fixed, dual-microphone technique. 'Penetrating' type sealants were found to have a less detrimental effect on sound absorption than those of a 'bridging' type. Originator-supplied keywords include: Sound absorption coefficients.

***Wesolowski, J.J.** **"An Overview of Indoor Air Quality."** **Journal of Environmental Health. Vol. 46, No. 6, 1984, pp. 311-316. (PA)**

This overview of nonoccupational indoor air quality covers such topics as the importance of indoor air quality, pollutant sources, differences between indoor and outdoor pollution, health effects, and measurement and mitigation techniques. It also describes the recently legislated California nonoccupational indoor air quality program.

***Woods, J.E., et al.** **"Calculation Methods to Assess Indoor Air Quality."** **ASHRAE Transactions, Vol. 89, No. 2B, 1983, p. 683. 84-006258. (EN)**

Indoor air quality is determined by the sources of contaminants and by methods used to control their concentrations. Procedures used to predict or mathematically assess indoor air quality and rates of pollutant generation, transfer, and removal are characterized. Spatial models are also explored; these can be used to calculate contaminant distributions within occupied spaces. The nature and limitations of single-zone, steady-state models of occupied spaces are review. Needed analytical improvements, such as better characterization of contaminant generation dynamics, are cited.

*U.S. GOVERNMENT PRINTING OFFICE : 1985 0-527-806/30566